

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 of this Pilot Work

The pilot work was constructed based on the original design established in 1st Work in Lao P.D.R. (refer to Sector B (Preparatory Study for Pilot Works)). The outline of this pilot work is summarized as shown in Table 3.1.

Table 3.1 Outline of Pilot Work at Wat Chom Cheng Site

1. Total length of execution: 240 m
2. Riverbank type: a) bank slope: 45 degree or less b) secondary deposits: loose sandy silt/silty sand
3. Design criteria: a) design flow velocity: 2.6 m/sec b) low water level with 5-year return period: 158.1 m, MSL
4. Construction type: a) Foot protection work (wooden pile groyne work, Soda Mattress) b) Slope protection work (wooden pile groyne work)
5. Main points to note: a) Number of groyne: 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 groyne: 20m d) 3 rows of wooden piles is arranged in a hound's tooth with spacing of 1m
6. Work items: a) preparatory works • temporary works and facilities • collection and transportation of materials b) groyne works • 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 Groyne Work applied for the bank protection in front of Wat Chom Cheng Site consists of sets of spaced groins. The interval of each groyne is set as 40m in the upstream 120m range, and spacing of 60m in the downstream 120m range. Offshore length of the groyne is 20m, considering the riverbed cross-section and an area to be protected. Spacing of groyne is generally 2-3 times of the length of groyne. Each groyne consists of 3 rows of wooden piles arranged in a hound's tooth with spacing of 1m. Every other set of groyne is protected by Soda mattress and rip-rap stones and connected each pile by tie-rod to avoid any damage due to possible local scoring around piles.

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

3.3 Construction Schedule

The Pilot Work was executed according to the schedule as shown in Table 3.2 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 Wat Chom Cheng site are composed of foot protection work (Soda Mattress, Wooden pile groyne work) and Slope protection work (Wooden pile groyne work).

Table 3.2 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		1 no./day		
Setting Soda Mattress	9	nos				2 nos/day

3.4 Construction Equipment and Materials

Main construction equipments and its working description utilized for the execution, main material used for the Pilot Work and its specification and local name of fascine material for Soda Mattress Work are almost the same as that for Ban Dongphosi site listed in Tables 2.3 to 2.5

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 3.1)



1) Stockpile in Kao Liao Stockyard



2) Barge and piling

Figure 3.1 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 Groyne Works

(1) Log Piling

<p>1) General Outline</p> <ul style="list-style-type: none"> • Wooden pile groyne work is one of permeable dyke groyne 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 3.2)</p> <ul style="list-style-type: none"> • Wooden pile is driven by backhoe • Wooden pile of every other groyne 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 planed 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 3.2 (1/2) Workflow of Wooden Log Piling



7) Riprap on the slope around connecting piles



8) View of completed groyne works

Figure 3.2 (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 (same as Figure 2.5 at Ban Dongphosi Site)</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 Rare</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. 	

(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 3.3)</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 3.3 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 of this Pilot Work

The pilot work was constructed based on the original design established in 1st Work in Lao P.D.R. (refer to Sector B (Preparatory Study for Pilot Works)). The outline of this pilot work is summarized as shown in Table 4.1.

Table 4.1 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 Sector B (Preparatory Study for Pilot Works).

4.3 Construction Schedule

The Pilot Work was executed according to the schedule as shown in Table 4.2 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 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.

Table 4.2 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	m ³			200m ³ /day	
Filling Laterite	660	m ³			200m ³ /day	
Slope Protection						
Protection with soda material	1100	m ²			200m ² /day	
Placing Riprap	200	m ³			200m ³ /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	m ³			170m ³ /day	

4.4 Construction Equipment and Materials

Main construction equipments and its working description utilized for the execution, main material used for the Pilot Work and its specification and local name of fascine material for Soda Mattress Work are almost the same as that for Ban Dongphosi site listed in Tables 2.3 to 2.5

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 4.1 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 4.1 Temporary Facilities and Works in Kao Liao Stockyard

4.5.2 Foundation Works

<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 4.2)</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 4.2 Workflow of Log Hurdle Work

4.5.3 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 (same as Figure 2.5 at Ban Dongphosi Site)</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. 	

(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 4.3)</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 4.3 Workflow of Installation of Soda Mattress

(3) Toe 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 4.4)</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 ($V=2,400 \text{ m}^3$, including riprap of Soda mattress)
<p>8) Production Rate</p> <ul style="list-style-type: none"> • Stone placing including the riprap on Soda mattress: $170 \text{ m}^3/\text{day}$
<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 4.4 Workflow of Toe Rubble Deposition

4.5.4 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. • 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)</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 Workflow of Earth Works

4.5.5 Slope Protection Works

(1) Cobble Stone with Willow Branch Works

<p>1) General Outline</p> <ul style="list-style-type: none"> • The structure 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 4.6)</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 4.6 Workflow of Cobble Stone with Willow Branch Works

SECTOR E

TEST OF SIMPLE VEGETATION RIVERBANK PROTECTION

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

**FINAL REPORT
VOLUME 4
-SUPPORTING REPORT-**

SECTOR E

TEST OF SIMPLE VEGETATION RIVERBANK PROTECTION

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SECTOR E

TEST OF SIMPLE VEGETATION RIVERBANK PROTECTION

This Sector E compiles all the processes and result of the Simple Vegetation Riverbank Protection conducted from January 2003 to February 2004.

1 EXECUTION OF SIMPLE VEGETATION RIVERBANK PROTECTION WORK

1.1 Outline

High-cost riverbank protection works is unrealistic measures for the banks forming continuous vertical cliff with low important riverine area. Small-scale vegetative riverbank protection works might be the possible measures to fix such bank soil where some sedimentation is found in the dry season. The implementation cost of the vegetative works is extremely low, though it requires several years before the work effects. Accordingly, the test of the works was executed in January - May 2003 with assistance of National University of Laos.

1.2 Execution of Simple Vegetation Riverbank Protection Works

1.2.1 Site Selection

The test of simple vegetation riverbank protection is executed in two sites with different riverbank condition. One is Nongheo site with eroded riverbank, the other is Chom Cheng site with deposited rich soil. Figure 1.1 shows the riverbank condition at Nongheo site and Chom Cheng site.



Riverbank condition in Nongheo site



Riverbank condition in Chom Cheng site

Figure 1.1 The Riverbank Condition of Two Sites

Willow materials were collected at Culture Park and near Japanese ambassador house, since different willow species grow at each site. Soda materials were collected at Danxi and Nongpen. Figure 1.2 shows the vegetation condition of willow materials collection site. Figure 1.3 shows the vegetation condition of Soda materials collection site. Figure 1.4 shows the locations of test sites and materials collection sites.



Vegetation condition in Culture Park



Vegetation condition in near Japanese Ambassador House

Figure 1.2 Vegetation Condition at Willow Materials Collection Sites



Figure 1.3 Vegetation Condition at Nongpen

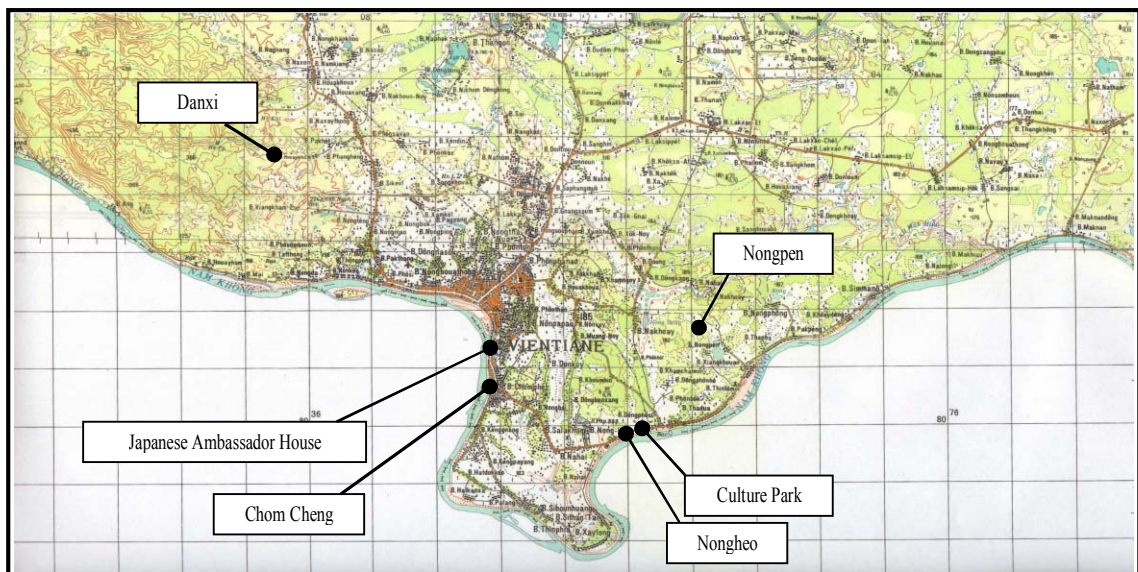


Figure 1.4 Location of the Test of Simple Vegetation Riverbank Protection and Material Collection Sites

1.2.2 Willow Planting Method

(1) Method of Planting Willow

The test was conducted by four methods as follows;

1. Bundled tree works: To bundle tree and willow twigs by strong wire, then to fix them by wooden short piles.
2. Soda-Net works: To make Soda-net of tree and willow twigs, wooden short piles.
3. Cutting works: To plant willow stump directly.
4. Seedling works: To plant willow seedling grown in pollybag.

Willow was planted as water level goes down from January to May, since water is needed for willow appearing.

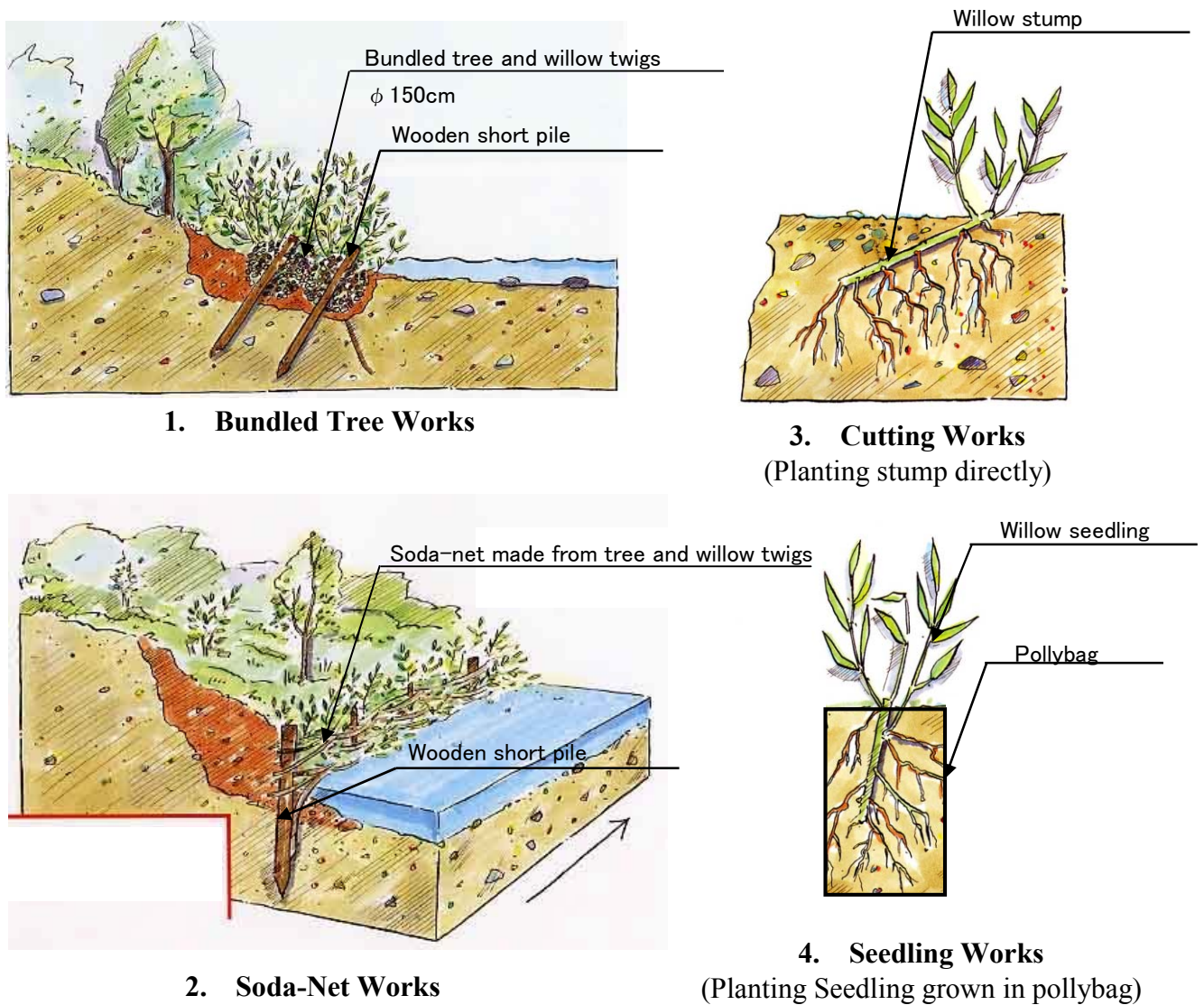


Figure 1.5 Methods of Planting Willow

(2) Materials

Bundled tree works and Soda-net were made of wooden materials. Table 1.1 shows the list of materials and Figure 1.6 shows materials used.

Table 1.1 Size of Willow Materials for Each Planting Method

Planting Method	Material
1. Bundled tree works	Twigs: Length=3m Short pile: Length=0.7m, ϕ 5cm Wire : ϕ 4mm
2. Soda-net works	Twigs (flexible): Length=3m Short pile: Length=0.9-1.2m, ϕ 5cm
3. Cutting works	Willow stump
4. Seedling Works	Seedling



Twigs Length=3m



Short piles Length=0.7m, 0.9-1.2m ϕ 5cm

Figure 1.6 Wooden Materials for Bundled Trees and Soda-Net

(3) Willow Materials

Collected willow materials were two species namely: Khai Nun (*Eugenia fluviatilis*), and Kok Khai (*Polyalthia corticosa*). Kok Khai (*Polyalthia corticosa*) is used for all of methods and Khai Nun (*Eugenia fluviatilis*) is used for all of cutting works and seedling works. Figure 1.7 shows two species of willow, Table 1.2 shows the size of willow materials for each method and Figure 1.8 shows willow materials used.



Kok Khai (*Polyalthia corticosa*)



Khai Nun (*Eugenia fluviatilis*)

Figure 1.7 Willow Species

Table 1.2 Size of Willow Materials for Each Planting Method

Planting Method	Size of willow material	Used species
1. Bundled tree works	Willow twigs Length=1.2m	Kok Khai (<i>Polyalthia corticosa</i>)
2. Soda-net works	Willow twigs Length=1.2m	Kok Khai (<i>Polyalthia corticosa</i>)
3. Cutting works	Willow stump Length=0.6m	Kok Khai (<i>Polyalthia corticosa</i>) Khai Nun (<i>Eugenia fluviatilis</i>)
4. Seedling Works	Seedling grown in pollybag	Kok Khai (<i>Polyalthia corticosa</i>) Khai Nun (<i>Eugenia fluviatilis</i>)



Left: Willow twigs Length 1.2m



Right: Willow stump Length 0.6m

Seedling grown in pollybag

Figure 1.8 Willow Materials

(4) Seedling Preparation

Nursery was established for seedling preparation, in which willow stump was planted in pollybag and watering was practiced every morning and evening by the members of Lao National University.

Seedling grows enough for three months. Table 1.3 shows the list of materials for seedling. Table 1.4 shows the schedule of seedling preparation. Figure 1.9 shows the situation of nursery.

Table 1.3 List of Materials for Seedling

Material	Size
Willow stump	Length=40-50cm
Pollybag	-
Soil	-
Sunscreen, Bamboo	Nursery establishment

Table 1.4 Schedule of Seedling Preparation

Activities	Jan./2003	Feb./2003	Mar./2003	Apr./2003	May/2003
Nursery establishment	—				
Seedling preparation(collecting materials)	—				
Watering	—	—	—	—	
Planting					—



Figure 1.9 Situation of Nursery

1.2.3 Planning and Design of Test Sites

The same methods, bundled tree works, Soda-net works, cutting works, and seedling works were implemented at two sites, Nongheo site and Chom Cheng site.

At Nongheo site, the trial plot size is 60 m x 8 m divided into 2 main blocks as shown in Figure 1.10. As for referring seedling works (willow grown in the pollybag) and for cutting (stump directly planting), combination of planting works and arrangement are as shown in Figure 1.10. Mixture of two species (*Polyalthia corticosa* and *Eugenia fluviatilis species*) were used. Cross-section A-A' and cross-section B-B' are as shown in Figure 1.11 and 1.12, respectively.

At Chom Cheng site, the plan of test site and arrangement of planting works are as shown in Figure 1.13. Cross-section C-C' is as shown in Figure 1.14.

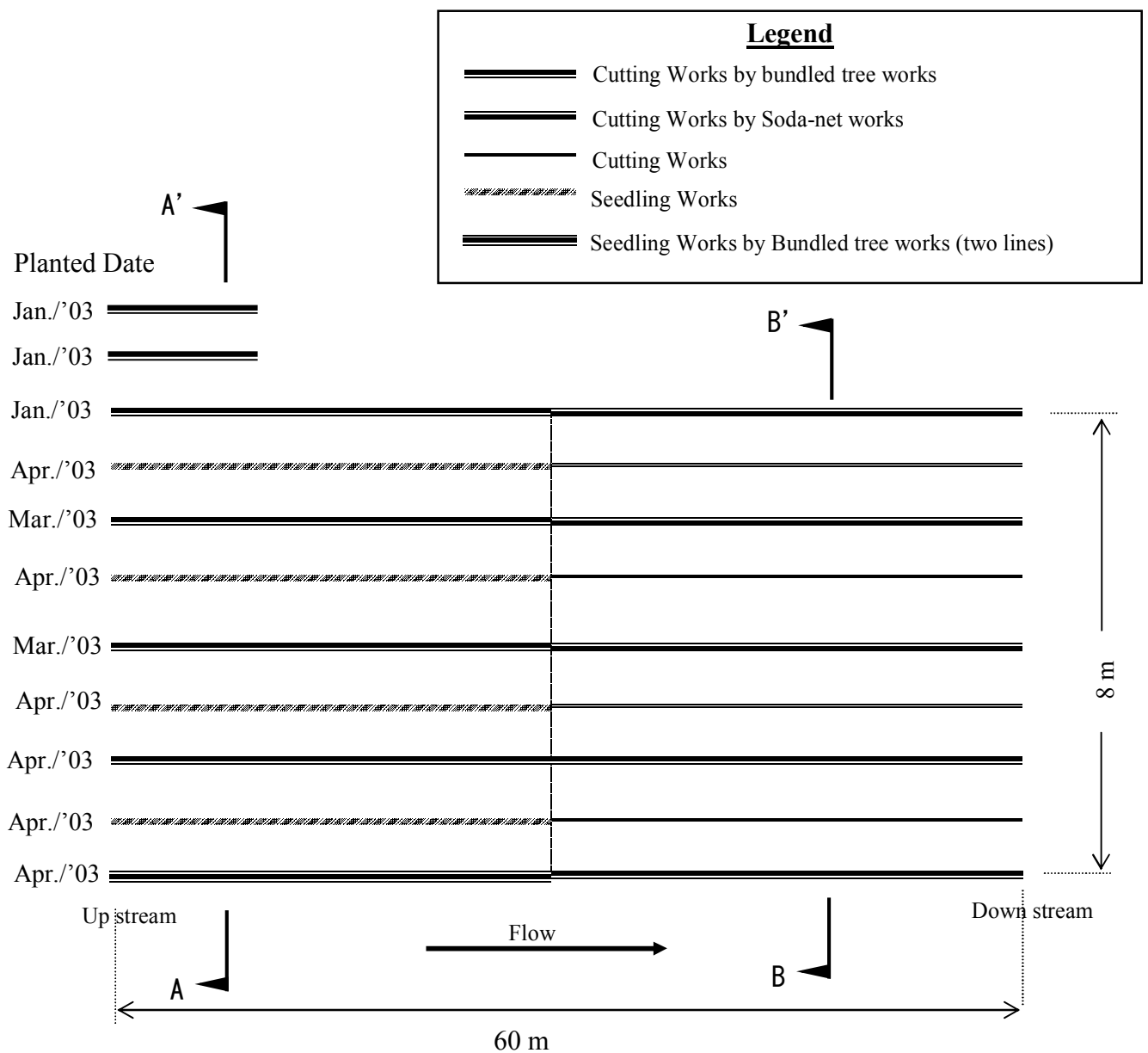


Figure 1.10 Plan of Test Site at Nongheo

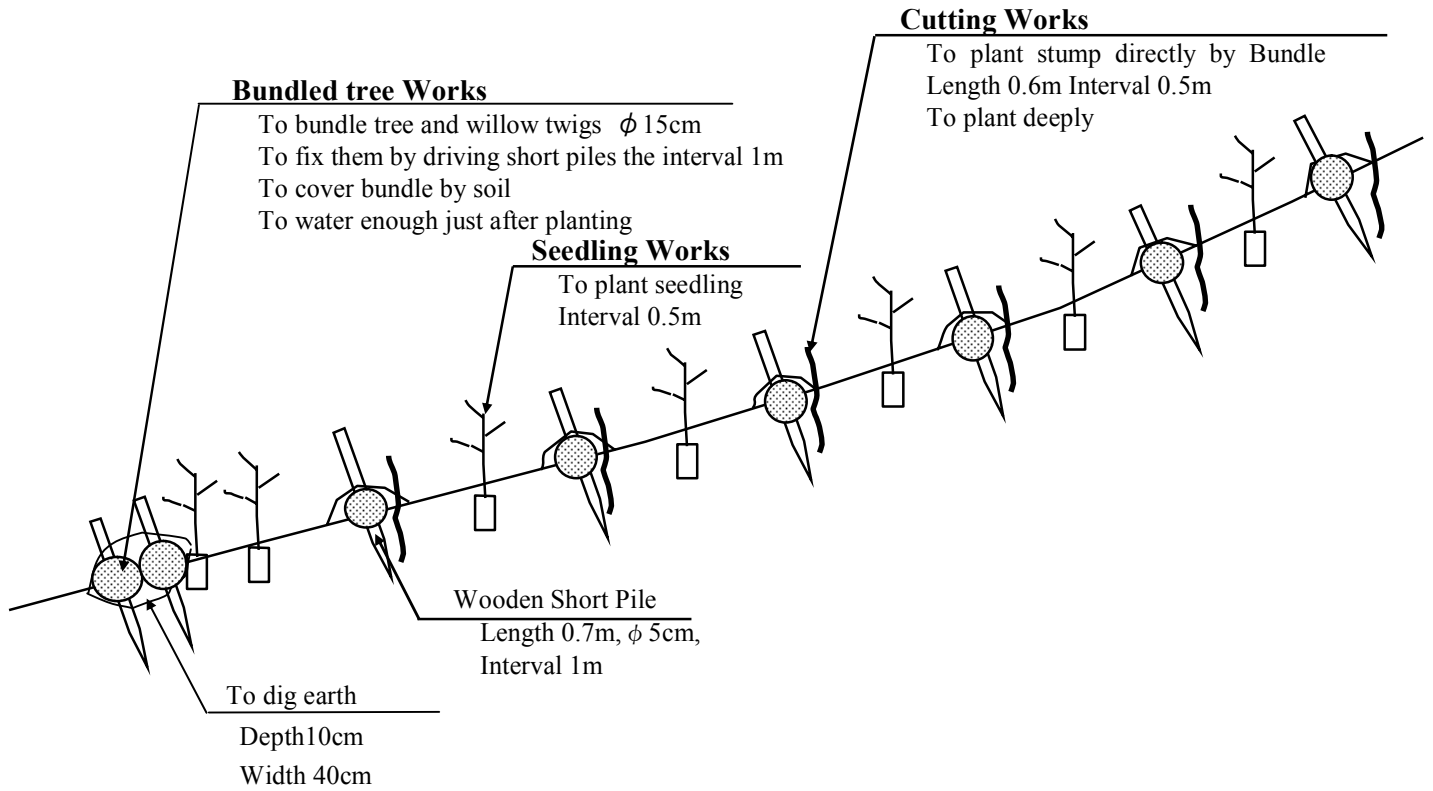


Figure 1.11 Cross-Section A – A' at Nongheo Site

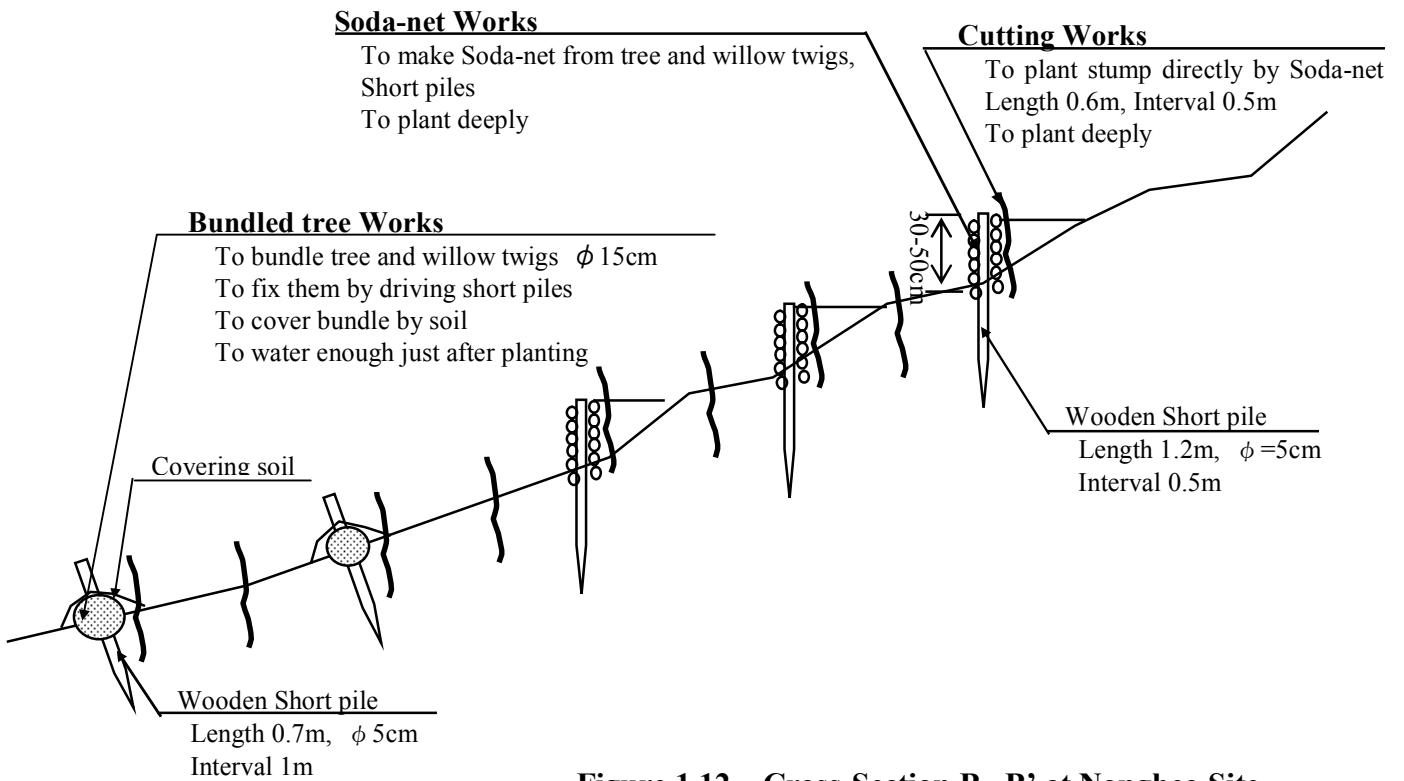


Figure 1.12 Cross-Section B –B' at Nongheo Site

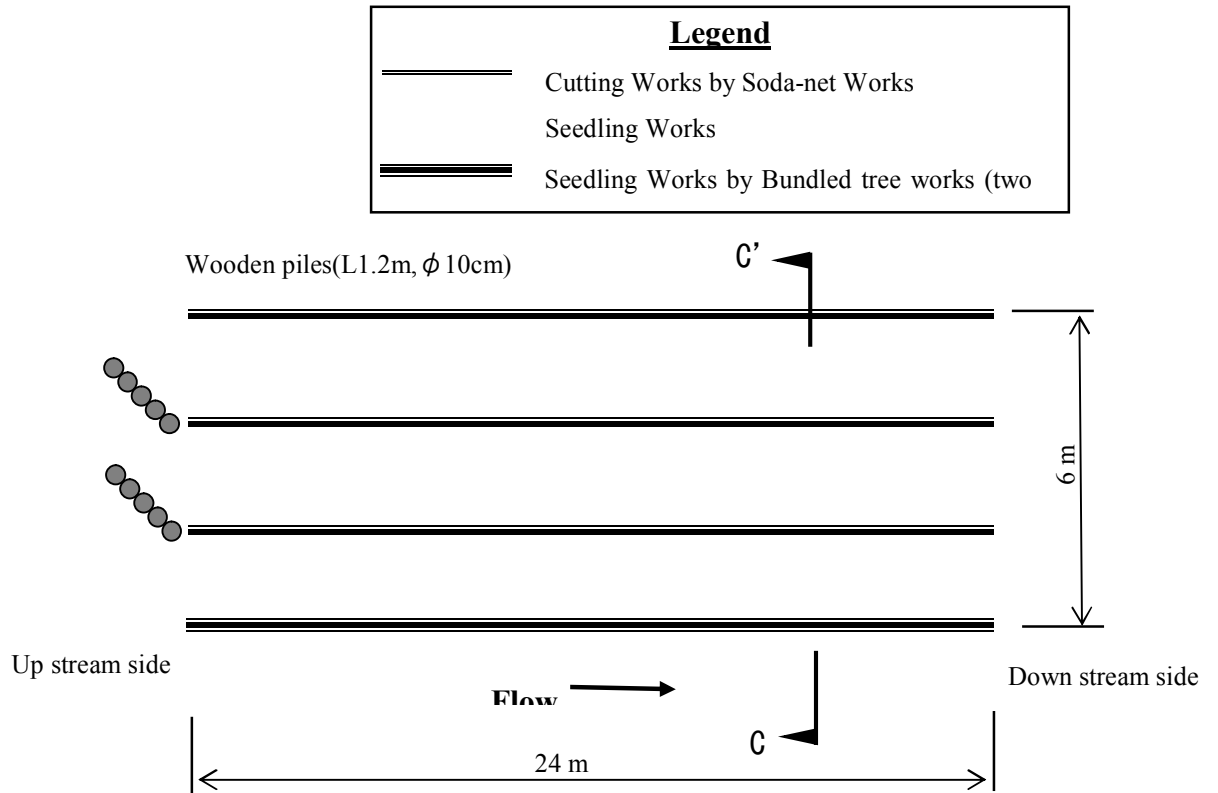


Figure 1.13 Plan at Chom Cheng Site

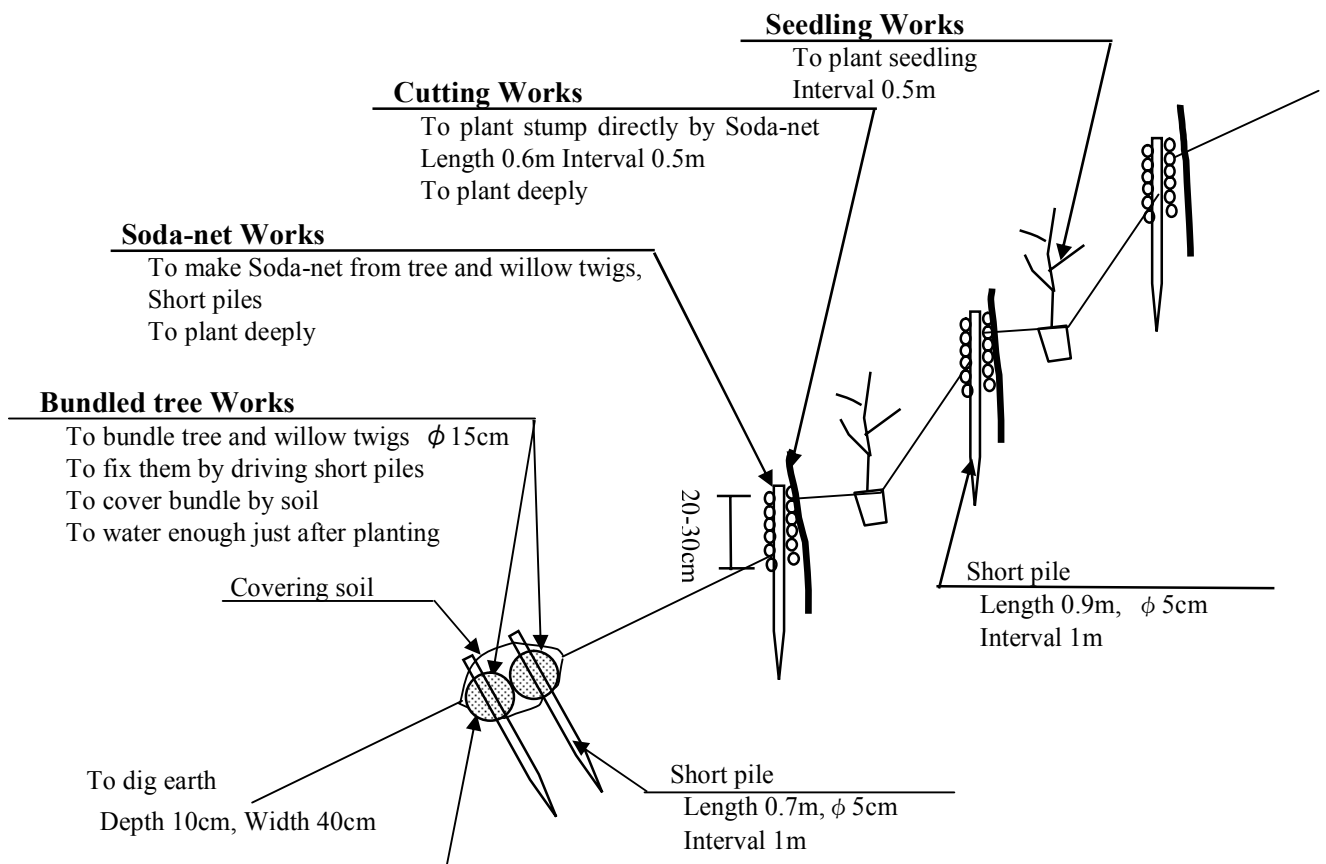


Figure 1.14 Cross-Section C-C' at Chom Cheng Site

1.2.4 Work Schedule

Work schedule is as shown in Table 1.5. Planting willow works started on January and continued to May. Stump directly planting was conducted during January to March in 2003. On the other hand, seedling was done in the period from April to May 2003.

Table 1.5 Work Schedule of Willow Planting

Activities	2003												
	1	2	3	4	5	6	7	8	9	10	11	12	
Nursery establishment, seedling preparation	—————												
Planting													
- Cutting Works (Stump Direct Planting)	—————												
- Seedling Works (Planting willow grown in the pollybag)				—————									

1.2.5 Execution of Planting Willow

Figures 1.14-15 show execution of planting willow at both sites of Nongheo and Chom Cheng. All activities were executed by the member of Lao National University under the supervision of JICA Study Team.



Completed Bundled tree works (Up stream Side)



Completed Soda-net Works (Down stream Side)



Driving short pile to fix bundled twigs



Situation of Making Soda-net
Planting willow deeply

Figure 1.15 Planting Willow at Nongheo Site



Completed Soda-net Works



Completed Seedling Works



Situation of planted willow connected Soda-net



Planting willow connecting twigs and short piles

Figure 1.16 Planting Willow at Chom Cheng Site

2 MONITORING OF SIMPLE VEGETATION RIVERBANK PROTECTION WORK

2.1 Monitoring Items and Schedule

Table 2.1 shows monitoring items and schedule.

Table 2.1 Monitoring Items and Schedule

Monitoring Place	Monitoring Items	Unit	Q'ty	2003												2004											
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Nongheo	Planting willow	Time	1	█					█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	
	Growth situation of willow	Time	1																								
	Reinforceing soda fence(including willow)	Time	1																								
Chom Cheng (Next Pilot work site)	Planting willow	Time	1	█					█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█		
	Growth situation of willow	Time	1																								

2.2 Result

Figure 2.1 shows photographs of willow at two sites in December 2003. Figure 2.2 shows photographs of willow at Nongheo sites in April 2004. Many willows grow at Nongheo site. However little willow grows at Chom Cheng site, since Soda-net was broken by water due to too soft earth.

2.2.1 Survival Rate

(1) Nongheo Site

Of the total 1000 planted willows from January 2003 (500 from seedlings and 500 stumps), there were 288 trees survived. It means that survival rate is around 29 %.

Data collection was also done in the 10 meters range of planting by seedling where on 5 lines 100 seedlings were planted. There were 44 trees were survived (44 % survived). However, among 100 trees planted by cutting, 23 were survived (23% survived) as shown in Table 2.2.

(2) Chom Cheng Site (Next Pilot Work Site)

Of the total 104 seedlings planted, there were only 3 survived. It means 2.8 % survived as shown in Table 2.2. Regarding the stump directly planting with the total of 104 stumps planted, there were only 7 survived (6.7% survived). The reason of low percentage is considered due to too soft soil condition, leading to erosion of all soda fences. Situation of survived willows at both sites are as shown in Figure 2.1.

Table 2.2 Survival Rate of Willow Plantation

Sites	Survival Rate	
	Seedling	Cutting
Nongheo*	44%	23%
Chom Cheng	2,88%	6,73%

Note: * Survival rate in the range of 10 m interval with watering



Up stream side in Nongheo site
Two planting methods were conducted,
bundled tree works and seedling works.



Down stream side in Nongheo site
Two planting methods were conducted,
Soda-net works and cutting works.



Chom Cheng site
Soda-net was broken due to earth too soft.

Figure 2.1 Situation of Willow Survived in December 2003



Up stream side in Nongheo site

Figure 2.2 Situation of Willow Survived in April 2004

2.2.2 Growth Performance

(1) Nongheo Site

A total of 23 trees planted by stump surveyed in the 10 m range at the left edge of the test site were measured. The results implied that the mean height was 17.7 cm, and the mean diameter was 3.6 cm. Planting by seedling was also measured. The number of trees survived in the 10 m range as mentioned above was 44. It was shown that the average height (19.1 cm) was higher than the stump directly planting and the mean diameter was 3.3 cm as shown in Table 2.3. Regarding the branch, an average length of branch was 24 cm while the mean branch number per tree was 4.8 branches. The maximum branch was around 9.3 and minimum was 4.6 branches. Situation of growth performance of willow at Nongheo site is as shown in Figure 2.3.

(2) Chom Cheng Site (Next Pilot Work Site)

Due to the too low survival rate, 100% of the trees (10 trees) were measured that include three from seedling planted and 7 from stump directly planted. The results imply that the mean height for the stump planting was 14.6 cm, while 21.4 cm was from seedling planted. However, the mean diameter shows that both two were quite similar between 2.6 cm and 2.8 cm. The average branch number per tree was 4.2 and average length was 21.5 cm as shown in Table 2.3.

Table 2.3 Growth Performance of the Willow Planted in Two Sites

Site	Cutting(mean)		Seedling(mean)		Branch(mean)	
	D (mm)	H (cm)	D (cm)	H (cm)	L (cm)	No.
Nongheo	3.6	17.7	3.3	19.1	24.0	4.8
Chom Cheng	2.6	14.6	2.8	21.4	21.5	4.2

2.2.3 Root Growth Performance

The results of root system growing in each site were quite different due to the method of planting such as seedling, the root system of which has stronger and the survival rate is higher than cutting method as shown in Table 2.4. Although the planting at Chom Cheng site was not successful, the root system was quite good compared with Nongheo site because of the very soft soil condition. Situation of growth performance of willow root is as shown in Figure 2.2.

Table 2.4 Root System growing of the Willow Plantation from 12/3/03 to 16/1/04

Site	Seedling		Cutting	
	Main root	Small root	Main root	Small root
Nongheo	No.= 3-10 roots D=0.1-0.9 Cm Length= 5-35 cm	No.= 16-75 roots D= very small Length=0,1-13 cm	No.= 3-10 roots D= 0.1-0.9 Cm Length= 5-55 cm	No.= 6-56 roots D= very small Length= 0,1-13 cm
Chom Cheng	No.=3-12 roots D=0.1-0.9 Cm Length= 5-75 cm	No.=13-86 roots D= very small Length=0.1-13 cm	No.= 3-10 roots D= 0.1-0.9 Cm Length= 5-35 cm	No.= 16-75 roots D= very small Length= 0.1-10 cm



Growth performance of willow appeared from bundled tree.
Up stream side in Nongheo site



Growth performance of willow appeared from soda-net.
Down stream side in Nongheo site



Growth performance of willow appeared from seedling.
Up stream side in Nongheo site



Growth performance of willow appeared from cutting.
Down stream side in Nongheo site

Figure 2.3 Growth Performance of Willow in January 2004

2.3 Recommendations

In conclusion, three methods of bundled tree works, Soda-net works and seedling works are available for willow growing. Moreover, cutting works, and stump directly planting are available if watering could be continuously done for a month after planting. However, in order to ensure the success of vegetation riverbank protection, it is necessary to make willow grow enough and to make the willow community formation.

It is important for willow planting as follows:

- To plant willow deeply by stump directly planting and by using Soda-net made of willow branch and Soda.
- To cover bundle tree with sufficient soil and enough watering just after planting.
- It is better to plant willow at the edge of water during in the period of water recession, as following water level going down.

Based on the finding of the test planting and experience, recommendations for the further vegetation riverbank protection works are thereby made:

- It is better to protect middle (upper) riverbank by tie-bundle of Soda hurdle work or Soda hurdle work as shown in Figure 2.4.
- To continue monitoring for several years in order to grasp the process and the time from planting to make the community formation. This will be useful for establishment of the simple vegetation riverbank protection works.

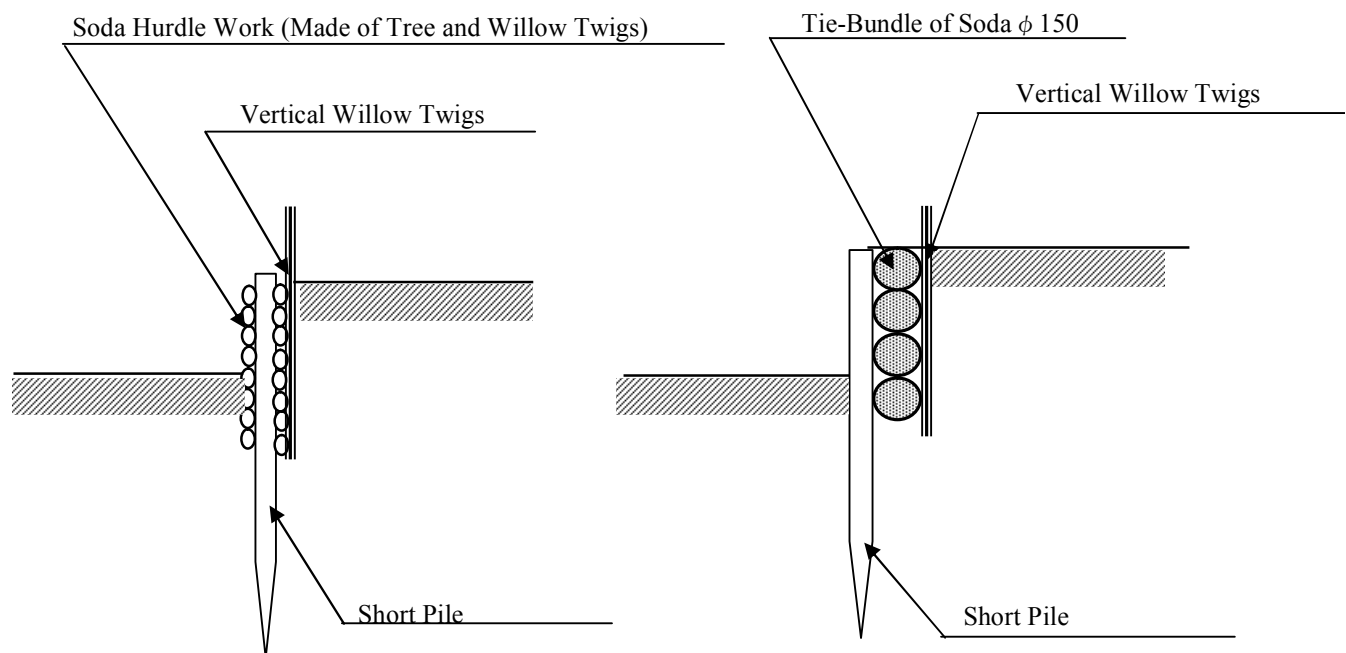


Figure 2.4 Recommendation of Middle Riverbank Protection