Department of Rural Roads
Ministry of Transportation
Kingdom of Thailand

Kingdom of Thailand
The Project for Bridge Master Plan and Bridge Maintenance Ability in Rural Area

Report 4
Flood Damage Rehabilitation Manual

July 2013

Japan International Cooperation Agency
CHODAI Co., Ltd
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Preamble

Since bridges overseen by the Department of Rural Roads(DRR) suffered damages, such as local scour on bridge abutments or inundation of roadways due to soil and sand movement and slides around edge row abutments, by the floods in Chao Phraya River Basin in 2011, these call for actions to implement urgent and sustainable measures.

In light of such problems, whereas references can be made to viewpoints and experiences concerning similar problems previously faced by Japan, when preparing this manual, we thereby adopt "Basic Policy for Disaster Rehabilitation to Protect Beautiful Mountains and Rivers" (June 2006) and "Draft of Detailed Inspection Guideline of Facilities such as Dikes etc. in the Management of Water Resources and Floodways (May 2011)" of the Ministry of Land, Infrastructure, Transport and Tourism as a basis for considerations.

This manual sorted normal inspection, inspection in abnormal conditions, flood damage assessment methodology and design of flood disaster measures. In the last Chapter, as examples of the design, we deal with two bridges selected as pilot projects among the 30 bridges urgently inspected in this project.

From now on, we hope this manual and the quick manual are utilized and DRR staff accumulate and renew knowledge to help the flood damage measures and rehabilitation as well as long-term maintenance and management of bridges.

Year 2013

Table of Contents

Chapter 1　Before Using this Manual

◇**Contents of this Chapter**

This Chapter explains firstly the objectives of preparing this manual, and then describes overall structure and the points of attention so that this manual could be as helpful as possible for users.　It is advisable that the users look through this Chapter as much as possible before going to the next Chapter.

1.1　Objectives of this Manual

Thailand faces flooding almost every year.　And after the disaster in 2011, which changed the Thai nation's attitude toward flood disaster, it attracts not only domestic but also worldwide attention and interest.

This Manual is constituted for the purpose of enabling DRR staff, as the administrator of rural roads, to prevent destabilization of piers and bridge abutments and bridge collapse caused by erosion or scouring of bank due to flooding.

1.2 Structure of the Manual

This whole Manual consists of 6 Chapters, each of which is based on the following view.

Chapter 1 is the guidance for users. This Chapter describes the objectives of preparing this Manual and explains overall structure for the users.

Chapter 2 aims at sorting the matters necessary for on-site inspection method. It explains dividing those matters into “Periodical inspection on normal time” and “Inspection method during disaster” caused by flood.

Chapter 3 describes the method of organizing the conditions of the areas to be restored for flood disaster assessment (Table A) and the method of calculating design current velocity during flood according to the information obtained from the inspection method during disaster prescribed in Chapter 2 (Table B).

Chapter 4 describes flood damage rehabilitation works, so as to choose the construction method using “standard drawing”, after clarifying “design current velocity” and “river attributes of the affected area”.

Chapter 5 explains the points to be considered to some detailed extent, so that DRR staff and private consultants, when participating in the design of flood measures, can understand the contents.

Chapter 6 shows some design examples.

The structure of this Manual can be briefly illustrated as the following page.

【Structure and view of the Manual】

Chapter	Purpose
Chapter 1 Before using this Manual	<u>Guidance of the manual</u> (To be looked through firstly to utilize the manual effectively)
Chapter 2 Actual site investigation method	<u>Explains basic matter of inspection method</u> (To be read to understand what to check on normal time and during disaster)
Chapter 3 Flood disaster assessment	<u>Explains method of organizing flood damage conditions</u> (To be read to understand what to do during the disaster)
Chapter 4 Flood disaster measure and rehabilitation plan	<u>Explains method of designing flood measures</u> (To be read by those who are involved in considering measures and designing work)
Chapter 5 Estimation of flood disaster rehabilitation cost	<u>Explains how to estimate cost for construction</u> (To be read by those who are involved in ordering construction work)
Chapter 6 Design Examples	<u>Explains actual examples of flood measures</u> (To be read by those who are involved in considering measures)

1.3 Points of Attention when Using the Manual

The duties related to flood damage rehabilitation plan are different according to the "standpoint of each person" such as DRR (Bureau of Central Administration, Bureau of Local Road Development, and Office of Province Rural Roads) staff or private consultants.

1.3.1 Points of Attention for Each User

(1) DRR staff

・DRR staff, responsible for disaster management, should look through every part of the Manual and grasp a whole image of the work during the disaster. In addition, it is necessary for each of them to fully understand the part related to their respective work in charge.

・Inspection on normal time requires DRR staff to lead periodical inspection for maintenance and repairs of bridge simultaneously; therefore the staff conducting the inspection should read carefully the relevant part (Chapter 2) in advance.

・Inspection during flooding needs quick response in the disordered period post-disaster; therefore, it is indispensable to repeat initial response training to be able to take prompt and proper measures.

(2) Private Consultants

・Engineers from private consultants are required to fully understand the relevant part of this Manual to use it as a reference as needed, when conducting inspection work or design work of flood measures.

1.3.2 Points of Attention regarding the Timing of Reading this Manual

As this Manual aims to be a help for flood damage rehabilitation, it is desirable to be read in advance, not after a disaster occurs.

Especially, the following items should be read beforehand to understand how to respond in case of disaster.

- ✓ Chapter 2 Actual site investigation method
- ✓ Chapter 3 Flood damage assessment method
- ✓ Chapter 4 Flood disaster measures and rehabilitation plan

1.3.3　Revision of this Manual

It is not possible to predict when any large-scale disaster happens.　Since every time disaster comes in different forms, as a new disaster occurs, responses and measures to disasters may be reviewed and improved from time to time.

Therefore, regarding this Manual, it is necessary to be filed in a way which enables addition and deletion easily, to be flexible for each revision.

Image1.3.1　Example of the type of filing when maintaining the Manual

Chapter 2　Actual Site Investigation Method

This Chapter explains about inspection on normal time (especially the condition of scouring of bridge) and inspection during flooding.

Any abnormality possibly affecting the river management facilities and the function regarding control of floodway, irrigation use and environment preservation can be caused by various factors and appear in different way in terms of time and place.

Therefore, it is necessary to conduct proper inspection periodically or after any big external power influences.

This Chapter treats the inspection conducted for the purpose of ensuring two functions of flood control which river and irrigation canal should have.

1) to ensure floodway necessary discharge capacity

2) to secure the necessary safety of the river control facilities such as dikes

2.1　Inspection on Normal Time

Actual site investigation of bridge described in “Manual of Inspection Survey and Assessment of Bridges” intends to check any changes in the bridge and peripheral topography due to water flow and the existence of factors which include potential destabilization.

Inspection on normal time is visualized filling in the prescribed form. Also, with regard to checking longitudinal slope of the water course, it is necessary to refer to hearing to the Irrigation Department and wide area of plane surveying plan (topographical map) showing extreme points.

2.1.1 Inspection Plan

Inspection plan shall be prepared to conduct proper inspection.

- ✓ Study of past documents and materials
  - ・Check the information inputted in the registry
  - ・Check, if any, materials on the surveys or repairs in the past
- ✓ Field survey
  - ・Check the condition of actual site in case the site condition is unknown.
- ✓ Inspection structure
  - ・Arrange the members conducting the inspection
- ✓ Inspection process
  - ・Decide the schedule of inspection
- ✓ Consultation with relevant administrators
  - ・Check if any permission shall be obtained beforehand from administrator other than DRR or the land owner
- ✓ Emergency contact system
  - ・Determine the contact system in case urgent traffic regulation or repair work is necessary.
  - ・Also determine the reporting procedure in case of any accident during the inspection.

2.1.2 Inspection method

- ✓ Inspection shall be <u>based upon visual inspection.</u> Simple measuring tools (poles and staffs) are used for measuring, as needed. If simple measuring tools are not enough for inspection because of the inspection timing or site condition, measuring equipments such as laser distance meter or total station shall be used according to necessity.
- ✓ When taking pictures, <u>measures or poles should be used together to show the extent of the abnormality.</u> Also, it is desirable to mark the abnormality or use another way to facilitate the observation.
- ✓ Special care should be taken when inspecting new structure, recent constructed part, or repaired part.

For the timing of inspection, <u>dry season (drought period)</u> is desirable. The following are the reasons.

- ・Lower water level compared to that in rainy season may enable easier under-bridge access.
- ・Visually perceptible area of the abutments and the foundation of piers become larger, which means larger area to inspect the existence of damage.
- ・By conducting the inspection together with the inspection of bridge, effective work improves the accuracy of inspection result.

2. 1. 3 Inspection Items

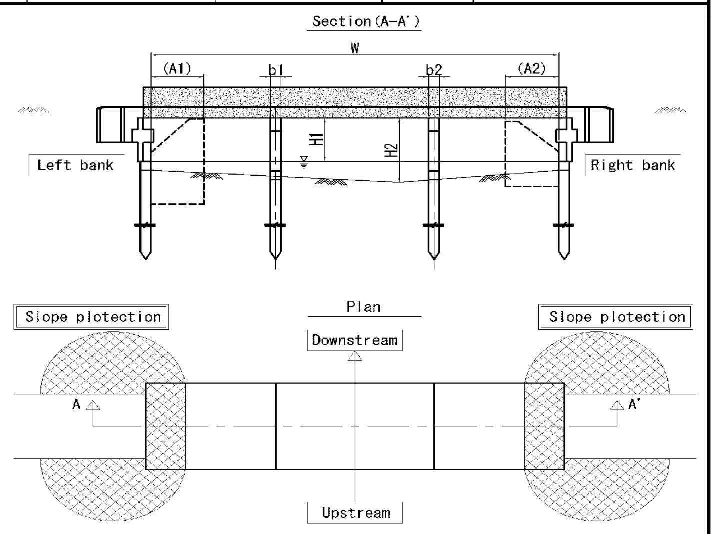
- ✓ longitudinal slope of riverbed
- ✓ water level
- ✓ present deepest height of riverbed
- ✓ flow section width
- ✓ obstruction width in cross sectional area (existing abutments, existing piles, etc.)

Bridge Data (For flood countermeasure&scouring)

Bridge Name	Sample（Temporary number : 1030-2)	Inspection Date	16/05/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N 15' 4' 36.95	Province	Lop Buri
Longitude	E 100' 40' 33.30	Main Inspector	(name)

Parameters	1	Riverbed slope		i	
	2	Water level		H_1	
	3	Maximum waterway depth		H_2	
	4	Water channel width		W	
	5	Total pier width	=b1+b2+(A1)+(A2)	bi	
	6	Flow hindrance ratio	=bi／W×100	R	

Bridge Profile



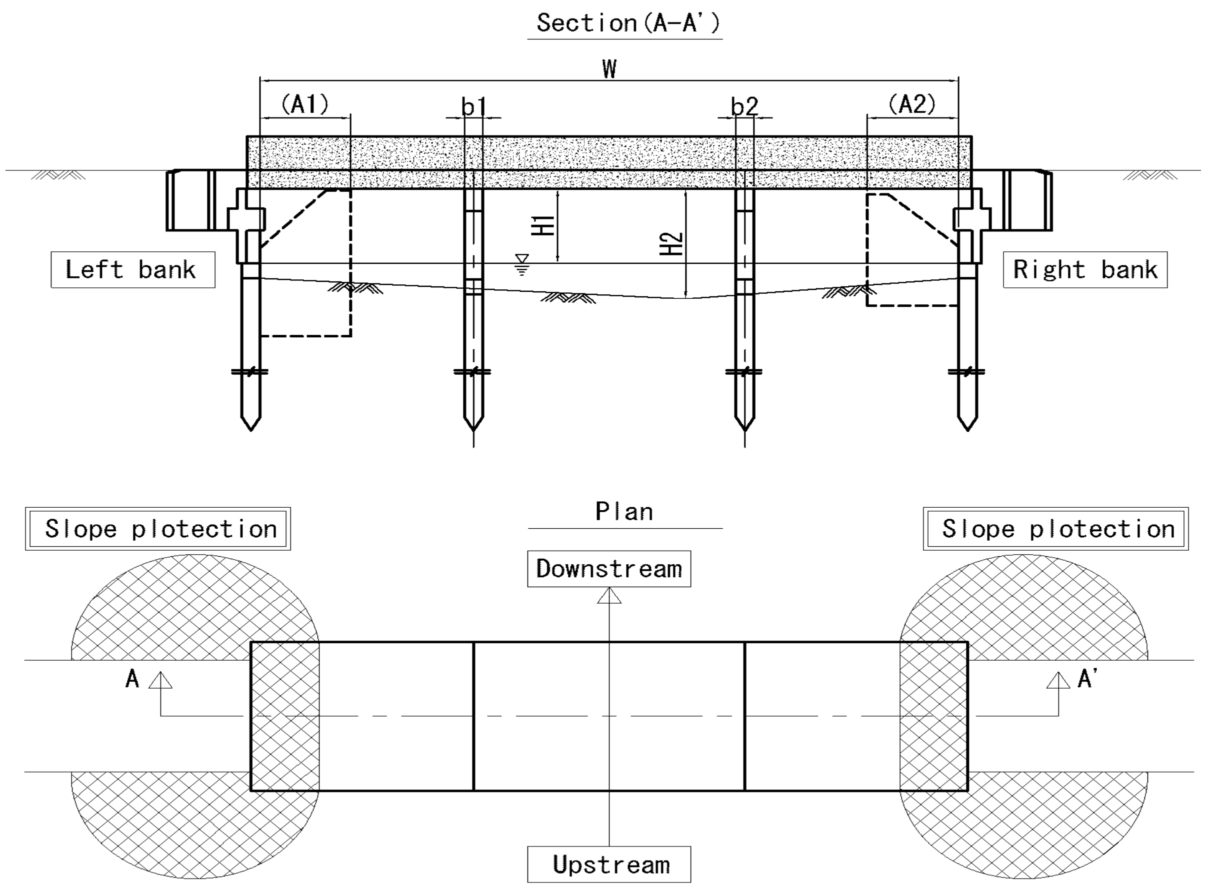
Existing slope protection	☐	Yes	☐	No
Damage due to flood disaster in the past	☐	Yes	☐	No
(Restoration construction)	☐ (Date)	Yes	☐	No
(Restoration method)				
Remarks				

Bridge Data　(For flood countermeasure&scouring)

Bridge Name	Sample（Temporary number：1030-2)	Inspection Date	16/05/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N　15' 4' 36.95	Province	Lop Buri
Longitude	E　100' 40' 33.30	Main Inspector	(name)

Parameters	1	Riverbed slope		i	
	2	Water level		H_1	
	3	Maximum waterway depth		H_2	
	4	Water channel width		W	
	5	Total pier width	=b1+b2+(A1)+(A2)	bi	
	6	Flow hindrance ratio	=bi／W×100	R	

Bridge Profile



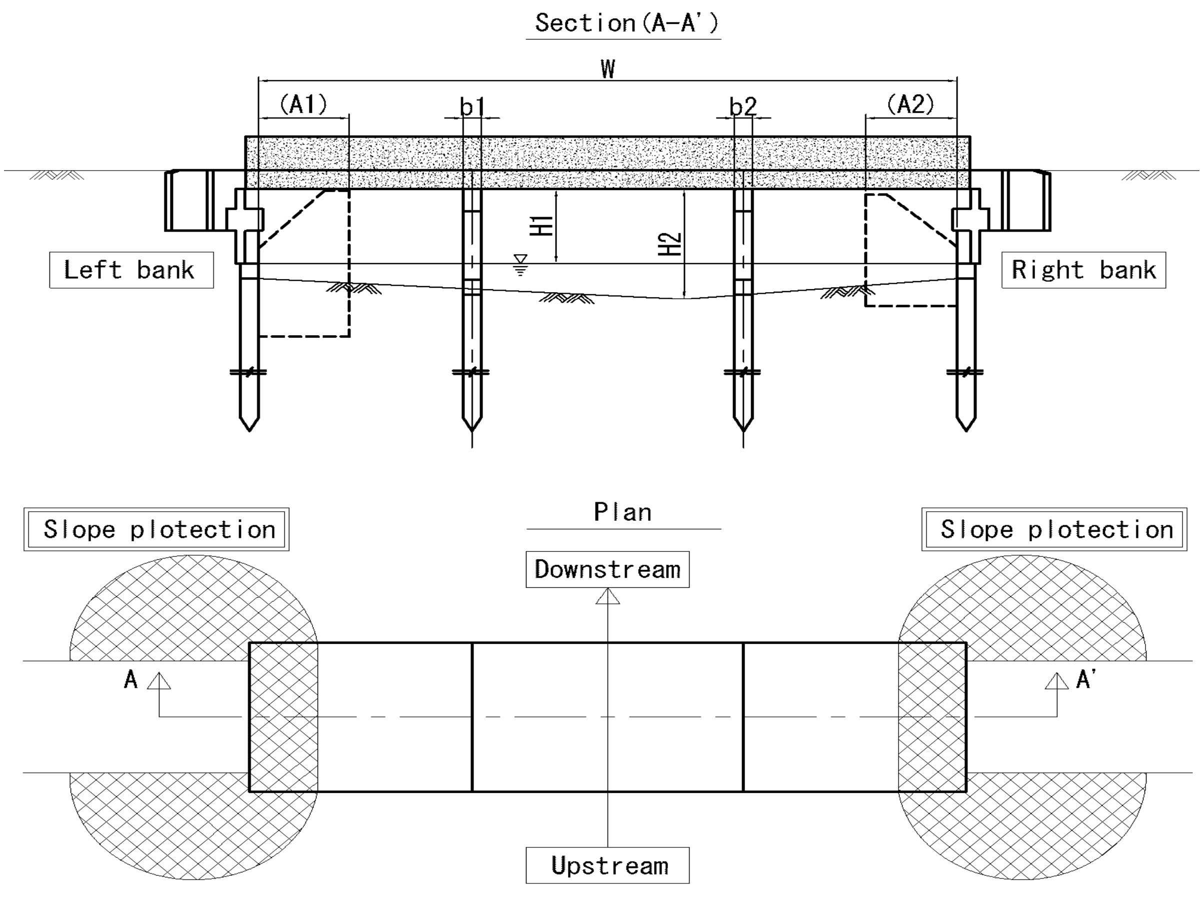
Existing slope protection	☐	Yes	☐	No
Damage due to flood disaster in the past	☐	Yes	☐	No
(Restoration construction)	☐	Yes	☐	No
	(Date)			
(Restoration method)				
Remarks				

Bridge Data (For flood countermeasure&scouring)

Bridge Name	Sample（Temporary number：1030-2)	Inspection Date	16/05/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N 15' 4' 36.95	Province	Lop Buri
Longitude	E 100' 40' 33.30	Main Inspector	(name)

Parameters	1	Riverbed slope		i	1/300
	2	Water level		H_1	2.9 (m)
	3	Maximum waterway depth		H_2	2.9 (m)
	4	Water channel width		W	15.4 (m)
	5	Total pier width	=b1+b2+(A1)+(A2)	bi	4.8 (m)
	6	Flow hindrance ratio	=bi／W×100	R	31%

Bridge Profile



Existing slope protection	☐	Yes	☑	No
Damage due to flood disaster in the past	☑	Yes	☐	No
(Restoration construction)	☑	Yes	☐	No
	(Date)	06/20/12		
(Restoration method)	Removed the existing pile			
Remarks				

2.1.4 Inspection Structure

The below is a draft of the members for the inspection team. With this draft for reference, considering the inspection items and actual site condition, etc., adequate members should be selected from engineers, technicians, and workers.

A person with enough knowledge and operational experience in the maintenance and management of rivers shall take charge of chief inspector. Inspection on normal time should be utilized as training for staff.

a) Chief inspector: 1 person (engineer)

A chief inspector leads the inspection work team, pays attention to the safety management, grasps action of each team member, and conducts inspection survey communicating closely with inspectors.

b) Inspectors: 2 or 3 people (technician or worker)

Inspectors conduct inspection work following directions of the chief inspector, and operate auxiliary devices and communicate or arrange with traffic controllers.

c) Traffic controllers: to be decided properly according to the traffic condition.

Traffic controllers prevent traffic obstacles during the inspection and secure the safety of the inspection workers.

2.1.5　Inspection equipments

For reference, inspection tools normally required are shown below.

Table2.1.1　List of inspection equipments for inspection on normal time(1/2)

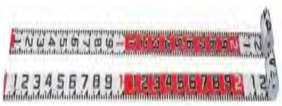
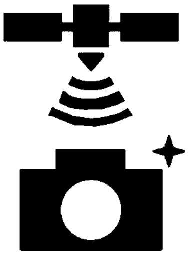
Type	Name	Use（Recommended specification）
Inspection tool	pole 	Used for measuring a short distance (telescoping pole of total length about 3 meters)
	staff 	Used for measuring a short distance (telescoping staff of total length about 5m)
	tape measure 	Used for measuring long distance (tape measure of total length about 50m)
	ribbon rod 	Used for measuring long distance (tape colored in white and red alternately for every 1m) (Convenient to prepare both 5m length and 30m length.)
	red cloth, red cloth tape 	Used attaching to the tape measure when the distance is too long

Table2.1.2 List of equipments for inspection on normal time(2/2)

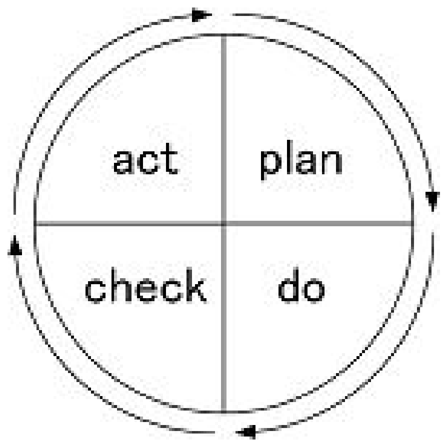
Type	Name	Use (recommended specification)
Recording tool	Camera 	To take pictures of the actual site condition and the damages (A camera with 1 million pixels or above and with GPS function is preferable.)
	Chalk, blackboard 	Used to record the explanation in the photo image
	Tablet PC 	Used to input inspection result
Auxiliary tool	Laser distance meter 	Used to measure distance when cross section of the river is too big to be measured directly by tape measure
	Flash light 	Used when inspecting in darkness of bridge clearance (One attachable to helmet is useful to move safely)
	Road safety/ regulation tool	For security during the inspection work(color cones, etc.)
	Safety equipment	Helmet, safety-belt, safety shoes

2.1.6 Frequency of inspection

Examples of other countries show that the most common frequency is once/about 5 years, except once/2years in the U.S. This Manual fix the frequency as “once /5 years” as default.

However, for the parts in which any damage due to floods is found or any repair work was done, the frequency shall be once/year, for the purpose of observation of the condition. When it is confirmed after the observation each year that any abnormality is not detected, the frequency shall be changed back to the default of once/5 year.

The inspection frequency shall be revised, same as in other countries, after some years of operation if necessary, as a part of PDCA cycle, according to the actual situation in Thailand.



2.2 Inspection during Flooding

In Thailand, floods tend to occur often meteorologically and geographically and cause huge damage to public works facilities every year.

Disaster rehabilitation project aims at fast rehabilitation of the affected public works facilities, and adjustment and facilitation of disaster rehabilitation measures are desired.

For this purpose, pictures of disaster condition which shows clearly the damage condition, topography, etc. are important materials for disaster rehabilitation design.

Moreover, the pictures of disaster condition also serve not only disaster assessment but also as the base of judgment when any change after the project is once decided occurs or a resurvey is conducted.

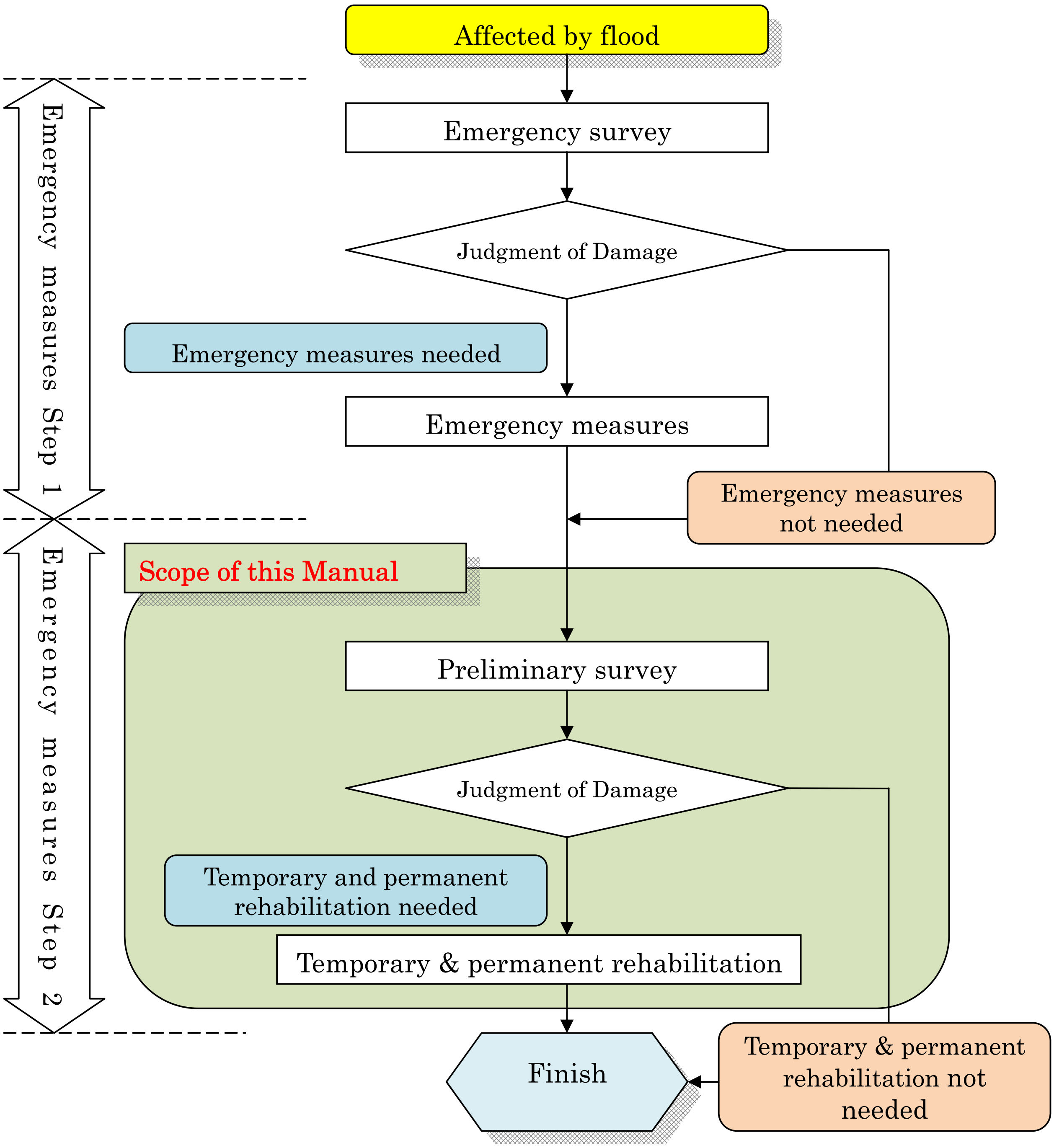


Image 2.2.1 Flowchart to examine rehabilitation plan for affected area

2.2.1 Inspection method

- ✓ In an inspection during flooding, measuring by simple measuring tools (poles and tape measures) shall be conducted. When the actual site condition makes inspection with the simple measuring tools difficult, “laser distance meter” or “detailed measuring devices such as total station” may be used according to necessity.
- ✓ In an inspection during flooding, photographing and sketching are basically carried out. To compare with the photos taken in the inspection on normal time for grasping the change of state, photos should be taken at the same angle, same scope, etc.
- ✓ In the inspection during flooding, “paper form” which is an excel sheet printed for handwriting shall be carried along.
- ✓ When photographing the damage, tape measures and poles should be used to show the extent of the damage. Also, it is recommendable to do the marking of the damage in the actual site to facilitate the observation of the damage.
- ✓ Result of the inspection shall be recorded in the prescribed forms. The way of recording should be paid attention to, so that the level of damage can be easily judged.
- ✓ When inspecting possible factors of obstruction in the cross sectional area of the river such as existing piles, special care shall be paid.

As for the timing of inspection, after the emergency measures have taken in response to the damage judgment in an emergency survey is desirable.

2.2.2 Inspection Items

- ✓ condition of the surroundings (houses or public structures)
- ✓ attachments to the bridge (water pipes)
- ✓ length of damage
- ✓ cross section of damage
- ✓ obstacles in flow section (existing abutments, existing piles, existing concrete remainder, etc.)
- ✓ cavities (length, depth)
- ✓ damage of the surrounding area of the bridge (damage in the edges of road, cavity in backside of abutments, etc.)

2.2.3 Inspection structure

It shall be based on the inspection structure for inspection on normal time. The number of members shall be determined according to the condition of damage.

2.2.4 Inspection equipments

The list of inspection equipments for inspection on normal time shall be treated as a base.

2. 2. 5 Order of photographing

Each photograph shall be taken with a concrete purpose to grasp precisely the condition of damaged area, and it is also necessary to pay attention to the order of attaching photographs.

As for the order of attaching photographs, photographs shall compose one story, as if they were explaining the actual site condition, organized so as to be examined in desk checking. And also, locations and directions of the photographs shall be shown in a plan or in the photograph showing the whole view of damage.

Here is a standard order of photographing.

① Whole view of the damage

- ✓ Plant poles at beginning and ending points, and stretch a colored tape to show the length.
- ✓ The beginning and ending points, survey points, and the distance between the survey points are recorded in “red color” in the photograph.

② Flood, condition of overtopping waves, marks of water level, flood fighting activities, etc.

③ Condition of the use of surrounding area

- ✓ photographs which show houses, roads, railways, public facilities, fields of rice or other crops
- ✓ may be omitted if the photograph ① can show

④ Events, fishing condition in the neighboring area

- ✓ When applying for a natural riverbank, photographs of the utilization of high water bed or hinterland are important explanatory materials.

⑤ Upstream/Downstream direction (front and back)

- ✓ Photographs should be taken to enable easy judgment of water flow direction (front and back), planting poles at beginning and ending point.
- ✓ Used as explanatory materials when selecting the method of construction.

⑥ Cross sectional photograph

- ✓ The cross sectional areas of main points shall be photographed placing poles and staffs. It will be more effective when such photographs are taken at survey points, as they can be used to compare with cross-section.

⑦ Other parts to apply for rehabilitation works

- ✓ Photographs shall be taken using poles and staffs to show the location and height.

⑧ Parts causing the damage

- ✓ Photographs shall be taken of the existing pier remaining and being a factor of obstruction in cross section area of the river.

2.2.6 Points of attention when photographing

The below are the points of attention when taking photos of the damage.

- ✓ When photographing, fell plants around the damaged point to clearly show the damaged point.
- ✓ So as to show the total length of the damage, be sure to place poles along the piles at beginning and ending point to see the distance. (When the length is too long, or the damage is too big, take overlapping photos to show the whole picture.)
- ✓ Contrive the way to see the cross-sectional topography easily. Also, take partial photographs according to type of construction or method of rehabilitation works.
- ✓ In the photograph, specify date, direction of water flow, beginning and ending point and distance, and in the plan, write direction of the photograph. When there are many photographs, give reference numbers.
- ✓ As for damage to the structures such as river revetments, photograph by showing the status of the damage by means of staffs and poles.
- ✓ Also attach general damage photographs, such as rise of river, flooding due to overtopping waves.
- ✓ Photograph toward upstream/downstream (front and back) directions at beginning and ending point, to show the condition of the facilities in front and back.
- ✓ Photograph as early as possible after disaster occurs.

2.2.7　How to photograph

(1) Photographing a short distance

If the distance is short of a few meters length, one shot photograph can show the total length of the damage, using poles, tape measures and red cloth, ribbon rod, etc.

(a) Photographing the front view

A clear photographic image can be taken from a point at which the camera parallels the damaged section.

Photo 2.2.1　example of measuring the length of damage using poles and a tape measure (together with red cloths)

Photo 2.2.2 Example of measuring the length of damage using poles and ribbon rod (1m pitch)

Photo 2.2.3　Example of measuring the length of damage using poles

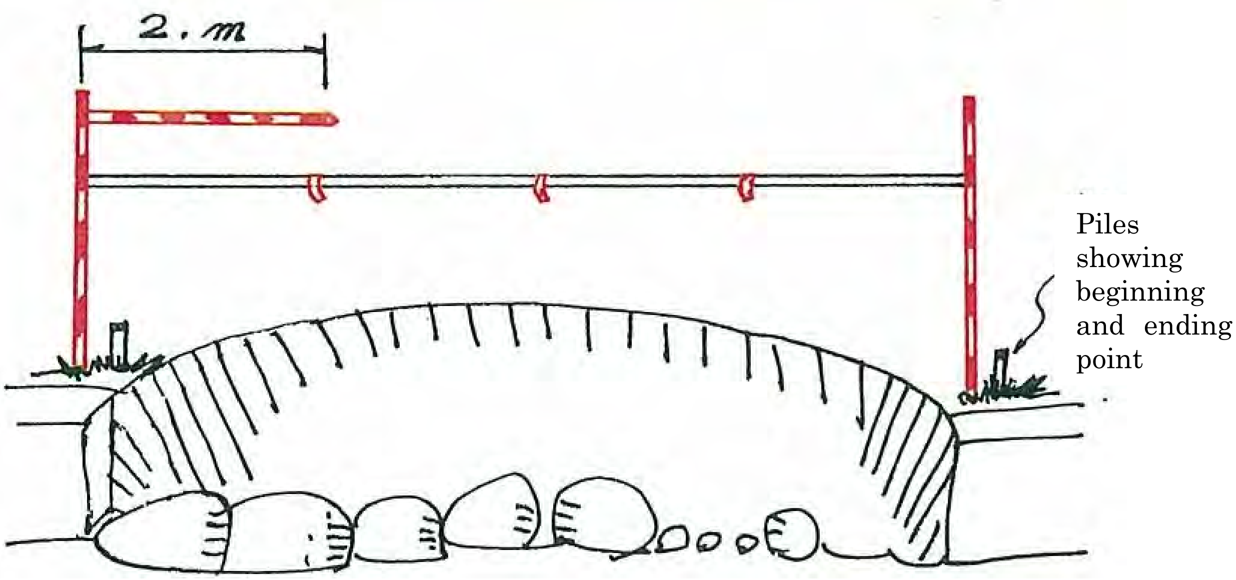


Image 2.2.2　Example of measuring the length of damage using poles and a tape measure (together with red cloths※)

※In case there is no ribbon rod colored red and white alternately for each 1m, using a tape measure, etc. with red cloths (slightly larger about 10cm x 50cm) knotted as marks at even intervals makes confirmation of the length of damage in a photograph easier.

（b）Photographing an oblique view

Due to the geographical reason, there is no choice but taking oblique photograph, special attention to be paid to the following matters.

- ✓ An extremely oblique photograph makes it difficult to prove the length in relation to the depth.
- ✓ As it is an oblique view, base of the poles and piles or the damage condition may be hidden by trees, plants, boulders.

Photo 2.2.4　Example of measuring the length of damage using poles and ribbon rod (1m pitch)

Photo2.2.5　Example of measuring the length of damage using poles and tape measure (together with red cloths)

(2) Photographing a long distance

When the distance is too long, for example, from ten meters to dozens of meters, one shot photo cannot grasp the whole view.

Also, even if a photograph of the whole view can be taken, it would be a long distance photo; therefore it is difficult to read the distance indication by tape, etc.

(a) Overlapping photos pivoting camera

There are some cases where overlapping photos are taken pivoting camera at the same point. In these cases, it can be thought of photographing with a wide-angle lens, however it is not desirable, as distortion of the photograph becomes bigger.

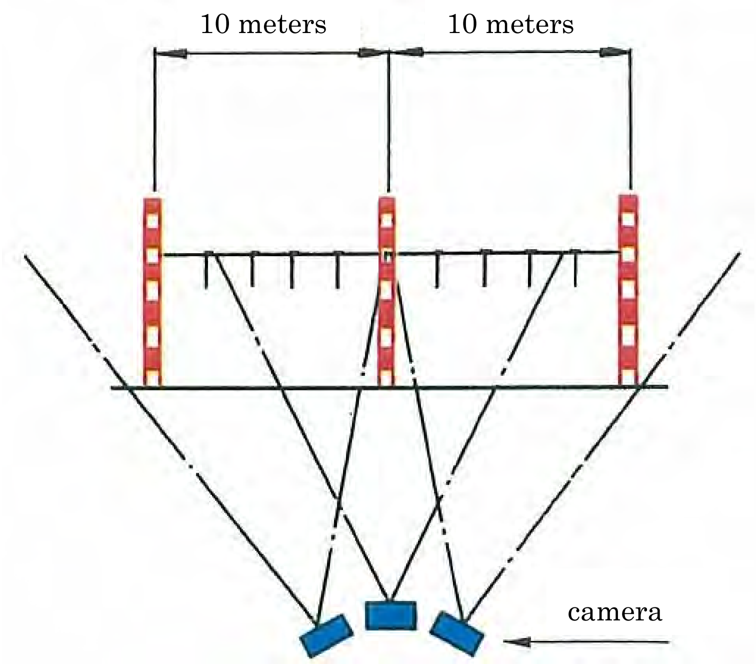


Image 2.2.3 How to photograph pivoting a camera (pasting the photographs together, overlapping about 50% of each)

（b）**Overlapping photos moving a camera to parallel direction**

There is another way that is moving the camera in parallel with the damage section. However, this way is difficult when overlapping. In this case, it is recommendable to set some fixed points (features of the damaged part, piles, etc.) and use some shots as they are.

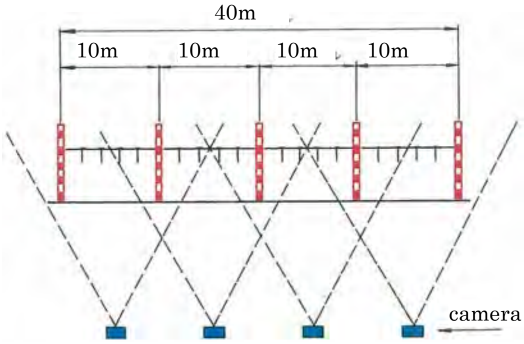


Image 2.2.4　How to photograph moving a camera (pasting the photographs together, overlapping about 50% of each, with the height and the distance of the camera fixed)

These two below are the photos of the same place.

Photo 2.2.6　Overlapping photos pivoting a camera

Photo 2.2.7　Overlapping photos moving a camera

(3) How to take a series of photographs changing photographing directions

When geographical circumstances allow only oblique photographs, the length is explained by a series of photographs, not only taking from both beginning and ending points, but also with supplementary photographs of the middle part.

Reference drawing of the method by which a series of photographs are taken changing directions when photographing

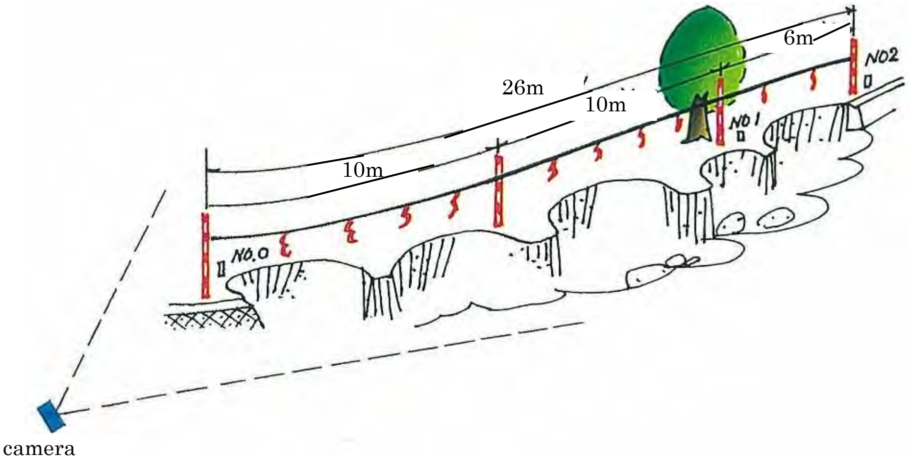


Image 2.2.5 Photographing only from the beginning point doesn't show the condition around the ending point

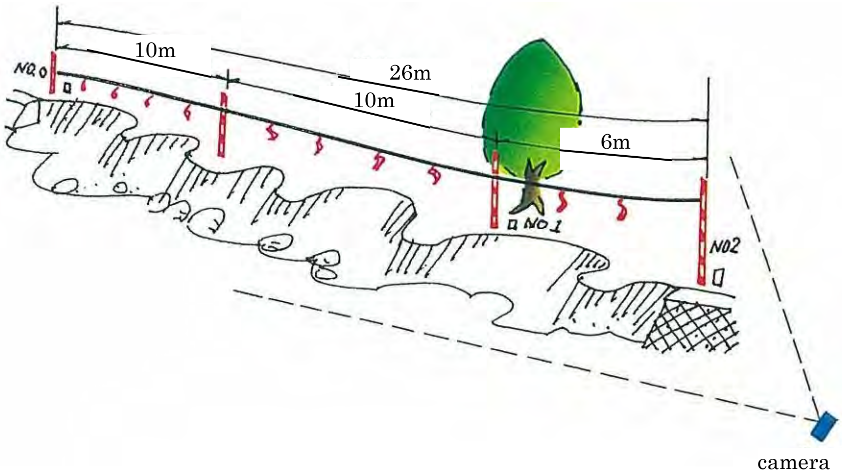


Image2.2.6 A photograph from the ending point supplements.

(※) It is recommendable to include some fixed points (in this case, a standing tree) in the photograph.

These two below are the photographs of the same place.

Photo 2.2.8　Photograph from the ending point

Photo 2.2.9　Photograph from the starting point

(4) **How to photograph a longer distance**

When the distance is too long to take photographs by the methods (1) to (3), photograph along with the facility.

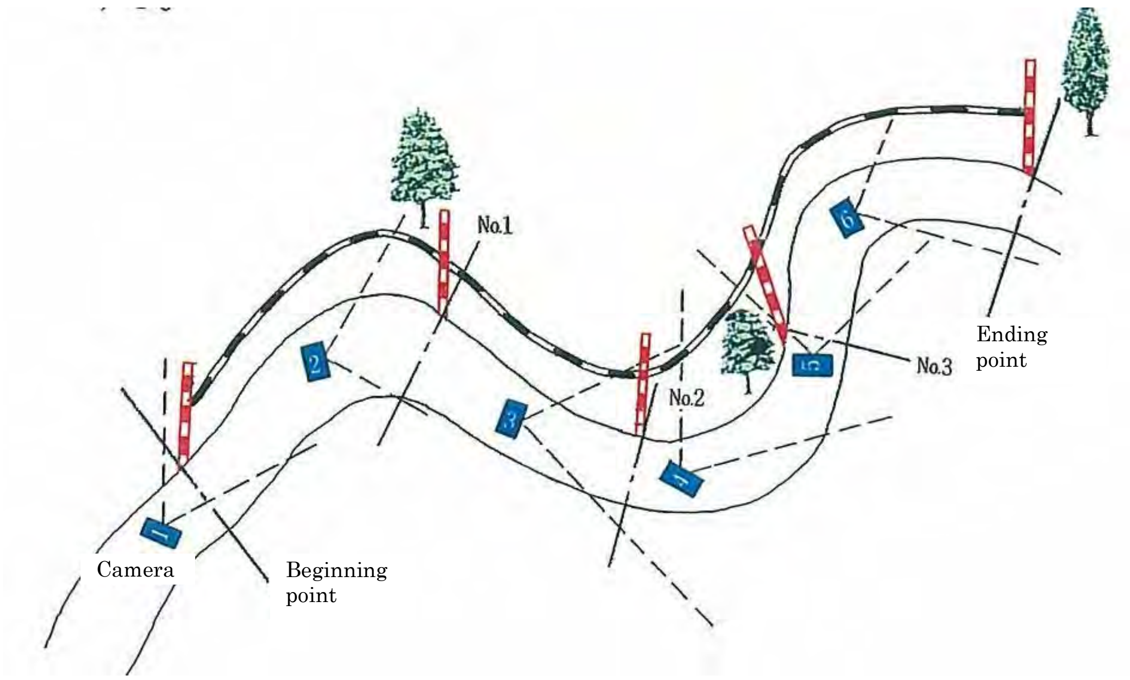


Image2.2.7　Method of taking a series of photographs from a longitudinal direction

(※) Movement of the camera should be limited within the scope where the tape can be read.　Be sure to take a fixed point in the photograph, forming a series of photographs by several shots.

(5) **How to photograph in case of a small cross-section.**

When the length of collapsed slope is as short as about 2m, one shot photograph can grasp the cross-section of the damage, using two poles or a combination of pole and staff.

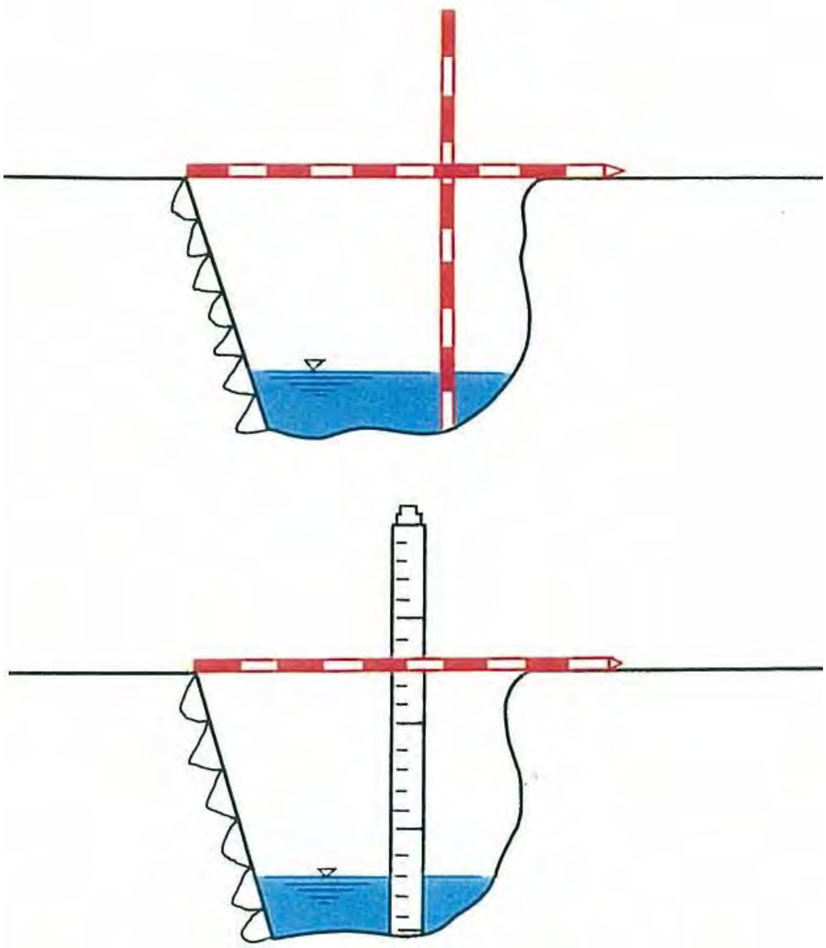


Image2.2.8　Method of photographing small cross-section by some two poles

(※) Measuring by using a staff sometimes makes reading of the length difficult in a photograph.　Using poles makes reading easier, though it is an approximate value.

Poles and staffs shall be placed horizontally or vertically when photographing.

Photo2.2.10　Measurement by poles

Photo2.2.11　Measurement by poles

(6) How to photograph a big cross-section

When the length of collapsed slope is big, in the same way as the distance is long, it is recommended to show in a series of photographs. That is placing poles in stepwise manner to show the horizontal distance and vertical height and photographing overlapping about 50% of each image.

When the poles in stepwise manner will be many steps but the slope is almost fixed, there is other method in which one stepwise set of poles is used to show the slope and a ribbon tape is used to show the distance.

These are the points of attention when photographing a cross-section.

- ✓ Be careful in respect of safety, as it is dangerous to work on a footing which easily collapses, such as collapsed surface or slid soil.
- ✓ Photograph after checking the actual site if obstacles such as plants or boulders hide the base of poles, etc.
- ✓ Set poles and staffs to be horizontal and vertical.

(a) When fixing a horizontal distance (or vertical height)

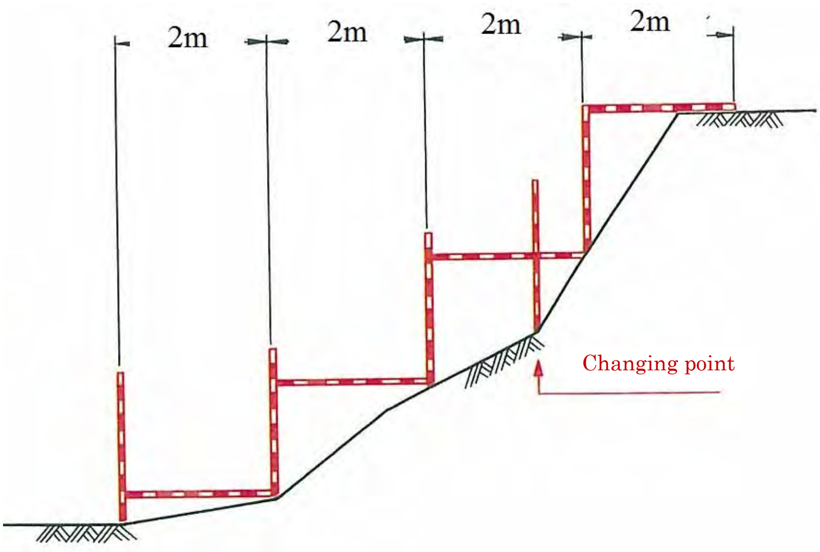


Image2.2.9　Measurement fixing a horizontal distance as 2m

(※) Plant a pole if there is any changing point.

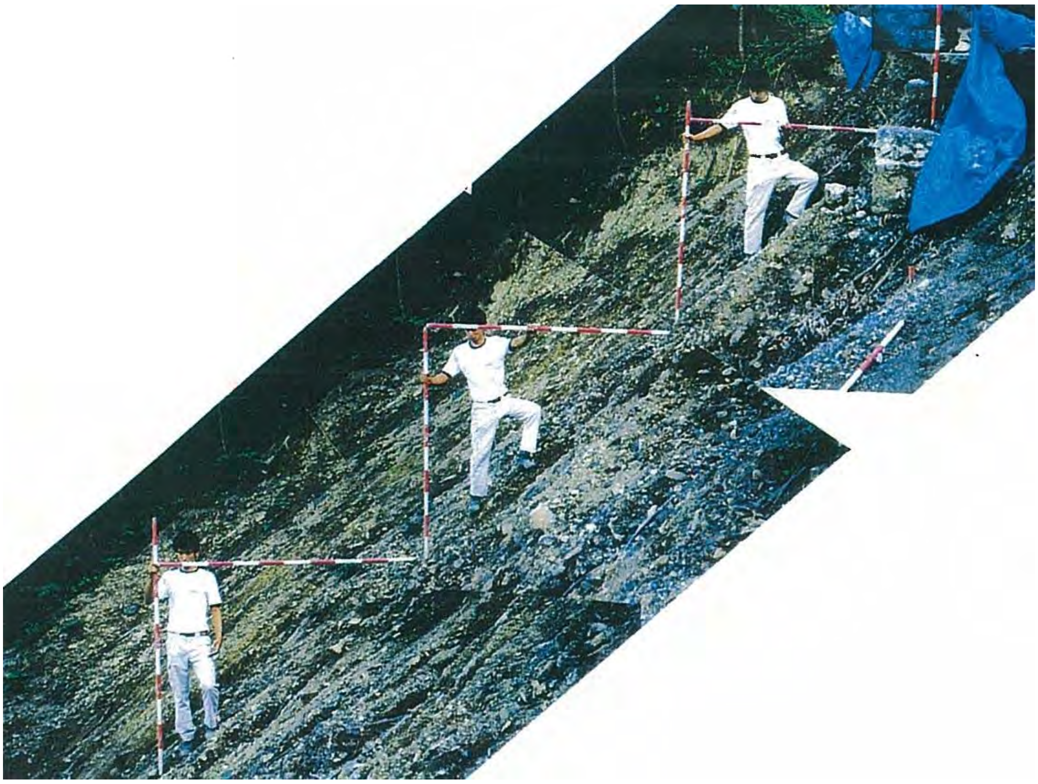


Photo2.2.12　Example when a length of collapsed slope is long

(b) When a slope is almost stable

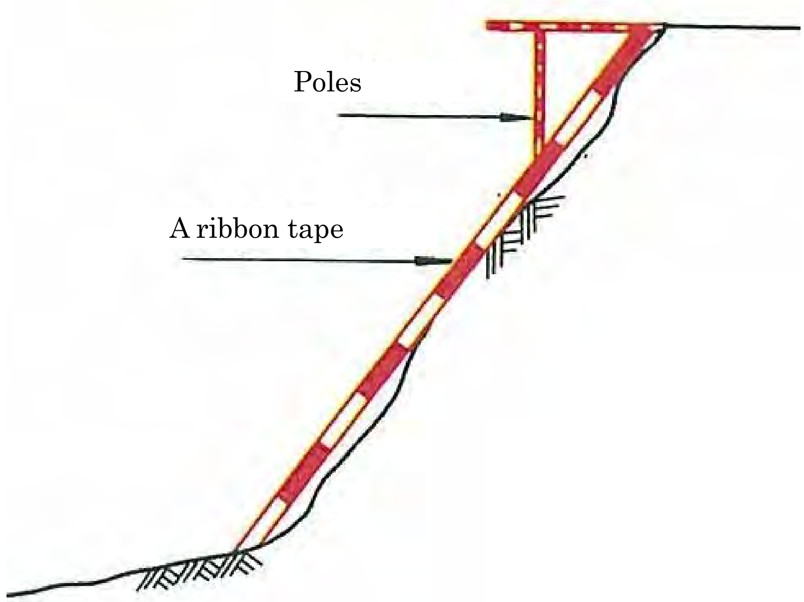


Image2.2.10　Example of measurement when a slope is stable

Photo2.2.13　Measurement when a slope is stable

（7）How to photograph damage condition of structures

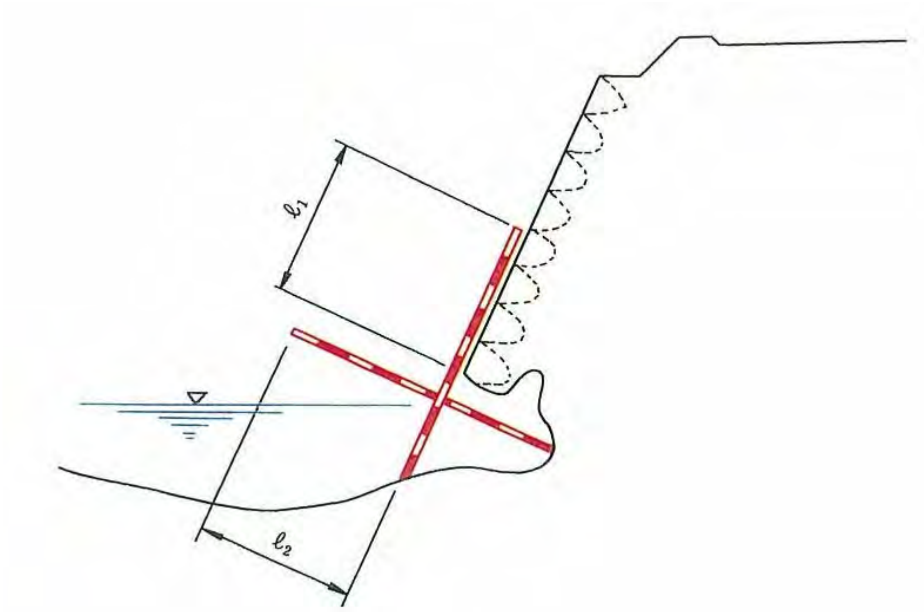


Image2.2.11　Example of measuring a caving

Photo2.2.14　Measurement of caving

Photo2.2.15　Measuring cross-section of an existing structure

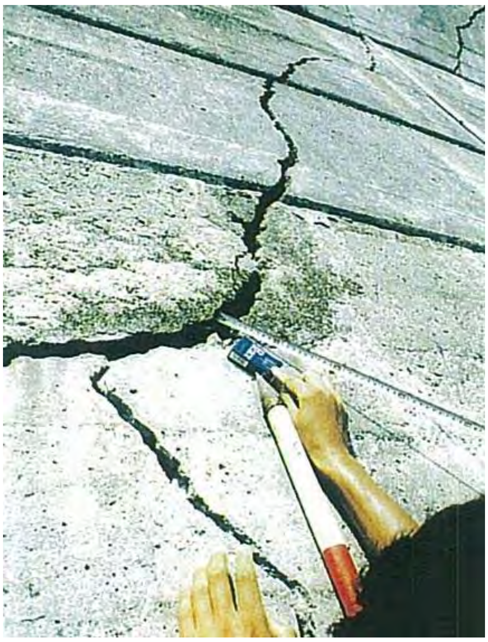


Photo2.2.16　Measuring cracks on a concrete retaining wall

Chapter 3 Flood Disaster Assessment

This Chapter explains the method of assessing the flood damage, utilizing the result of actual site investigation mentioned in Chapter 2.

When selecting a rehabilitation method, a method which enables to counteract the cause of the damage in accordance with the result of actual site investigation and to preserve and restore the previous river environment should be selected.

3.1 Table showing river attributes where rehabilitation is undertaken (Table A)

Prepare Table A when drafting a construction and rehabilitation plan. Table A will be presented at a meeting and while conducting damage assessment review.

【Additional chapter】

- ✓ Table A is a basic document prepared for understanding of causes of damages and river attributes, such as conditions of the river where damages exist and of surrounding area, which are observed while conducting a field survey and for drafting of a construction and rehabilitation plan.
- ✓ When preparing Table A, field staff should make a careful observation of the actual site and then prepare Table A-1 and Table A-2 successively.

Table showing river attributes where rehabilitation is undertaken (Table A)

Bridge Name		
Location		
Latitude	N	
Longtitude	E	

Inspection Date	
Route Number	
Province	
Main Inspector	

Present conditions before rehabilitation					
River and road conditions	Length of damage				
	Damaged facilities	☐ Dike · ☐ Embankment · ☐ Foundation reinforcement · ☐ Others			
	Channel variation	☐ Upward trend · ☐ Downward · ☐ Unchanged			
	River conditions	☐ Straight line · ☐ Bend			
Existing embankment	Position	Year of construction	Type	Slope	Detailed structure
	Related position	None			
	Upstream	None			
	Downstream	None			
Attributes of river and road	Cross section	☐ Single cross section · ☐ Multiple cross sections			
	Structure	☐ Adjacent to mountain · ☐ Deep excavation · ☐ Dike			
Channel materials	Soil condition	☐ Clay · ☐ Sand · ☐ Gravel · ☐ Stone · ☐ Others			
	Diameter of sample particles				

General example	
Fill out each item by filling it with colors below	
(yellow)	Manually key in numbers and text in the topic
(green)	Choose item which is within the scope
(pink)	Automatically calculated by excel program

Determining construction and rehabilitation methods		
(1) Desired goal of river environment	Natural environment that stimulates vitality of plants and animals	
(2) Scenery	☐ Vegetation · ☐ Stone · ☐ Concrete · ☐ Others	
(3) Inspection topics (※Calculation method refers to Table B)	Slope of refurbished embankment	
	Design current velocity	
(4) Conditions of surrounding areas		
(5) Basis for selection of construction and rehabilitation methods		
(6) Others		

Determining construction and rehabilitation methods		
Slope in construction and rehabilitation methods	☐ Slope ratio less than 1:1.5 ⇒ set in (Table C)	
	☐ Slope ratio greater than 1:1.5 ⇒ set in (Table D)	
Construction method		
Rehabilitation area		
Unit price of construction method		
Estimated construction cost		

Table showing river attributes where rehabilitation is undertaken (Table A)

Bridge Name	Sample (Temporary number : 1030-2)	
Location	Thalung Lek, Khok Samrong, Lop Buri	
Latitude	N	15.076
Longtitude	E	100.675

Inspection Date	26/01/2012
Route Number	1030
Province	Lop Buri
Main Inspector	(name)

Present conditions before rehabilitation

River and road conditions	Length of damage	50(m)			
	Damaged facilities	☐ Dike	☐ Embankment	☐ Foundation reinforcement	☐ Others
	Channel variation	☐ Upward trend	☐ Downward	☑ Unchanged	
	River conditions	☑ Straight line	☐ Bend		
Existing embankment	Position	Year of construction	Type	Slope	Detailed structure
	Related position	None			
	Upstream	None			
	Downstream	None			
Attributes of river and road	Cross section	☑ Single cross section	☐ Multiple cross sections		
	Structure	☐ Adjacent to mountain	☑ Deep excavation	☐ Dike	
Channel materials	Soil condition	☑ Clay	☐ Sand	☐ Gravel	☐ Rock · ☐ Others
	Diameter of sample particles	0.5(mm)			

General example

Fill out each item by filling it with colors below

Colour	Meaning
(yellow)	Manually key in numbers and text in the topic
(green)	Choose item which is within the scope
(pink)	Automatically calculated by excel program

Determining construction and rehabilitation methods

(1) Desired goal of river environment	Natural environment that stimulates vitality of plants and animals	
(2) Scenery	☐ Vegetation · ☐ Stone · ☑ Concrete · ☑ Others	
(3) Inspection topics (※Calculation method refers to Table B)	Slope of refurbished embankment	1:1.0
	Design current velocity	2.3(m/s)
(4) Conditions of surrounding areas	Paddy field	
(5) Basis for selection of construction and rehabilitation methods		
(6) Others		

Determining construction and rehabilitation methods

Slope in construction and rehabilitation methods	☐	Slope ratio less than 1:1.5 ⇒ set in (Table C)
	☑	Slope ratio greater than 1:1.5 ⇒ set in (Table D)
Construction method	D-2	Multiple-layered wire mesh boxes
Rehabilitation area	500 (m^2)	
Unit price of construction method	13500 (yen /m^2)	
Estimated construction cost	6,750,000 (yen)	

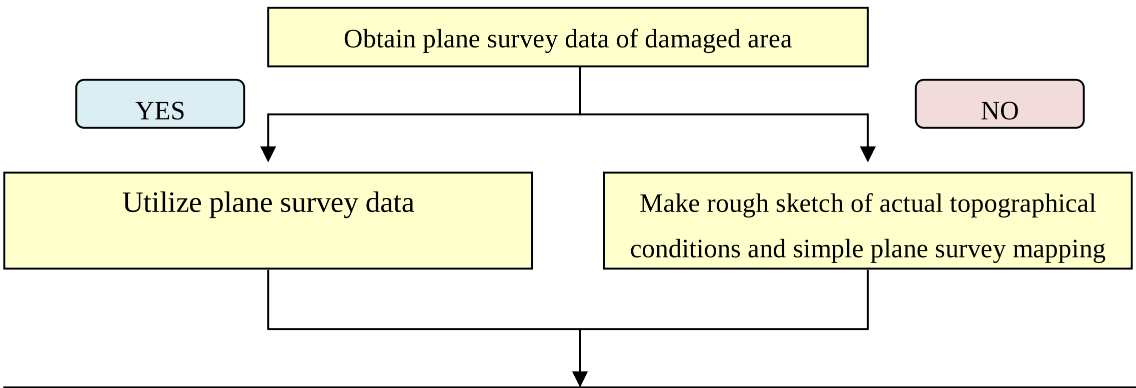
3.1.1 Table showing damage conditions (Table A-1)

When contemplating rehabilitation measures, it is necessary that one must understand topography of damaged conditions where detailed aerial and measurement surveys are conducted if such information will be used.

If measurement survey data are not available, instruments such as measuring tape, staff or pole or laser-guided measuring device must be used at the actual site. In addition, overall topographical conditions at the actual site must also be sketched.

Moreover, measurement survey must include cross sections of upstream, midstream and downstream areas which represent three positions marking the perimeter of damaged area. Such data must be input in Table B and written down in an itemized list.

【Summary details of the preparation procedure (Table A-1) 】



- ✓ Note the length and depth of damages, using the scope which can be inspected and measured.
- ✓ Note flow directions on a plane survey map.
- ✓ Note cross sections of damages whereby such data must be input in Table B.
  - ➢ Make cross section survey and measurement of upstream, midstream and downstream zones of damaged area.
  - ➢ In case there is any substantial pattern change aside from three cross sections, inspection and measurement must be undertaken separately.
- ✓ Note directions and assign numbers for used pictures in Table A-2

Table for refurbishing damage conditions (Table A-1)

Bridge Name			Inspection Date	
Location			Route Number	
Latitude	N		Province	
Longitude	E		Main Inspector	

Make survey plane drawing, note length of damages and damage conditions

↓

Note cross sections of damages (upstream, midstream, downstream)

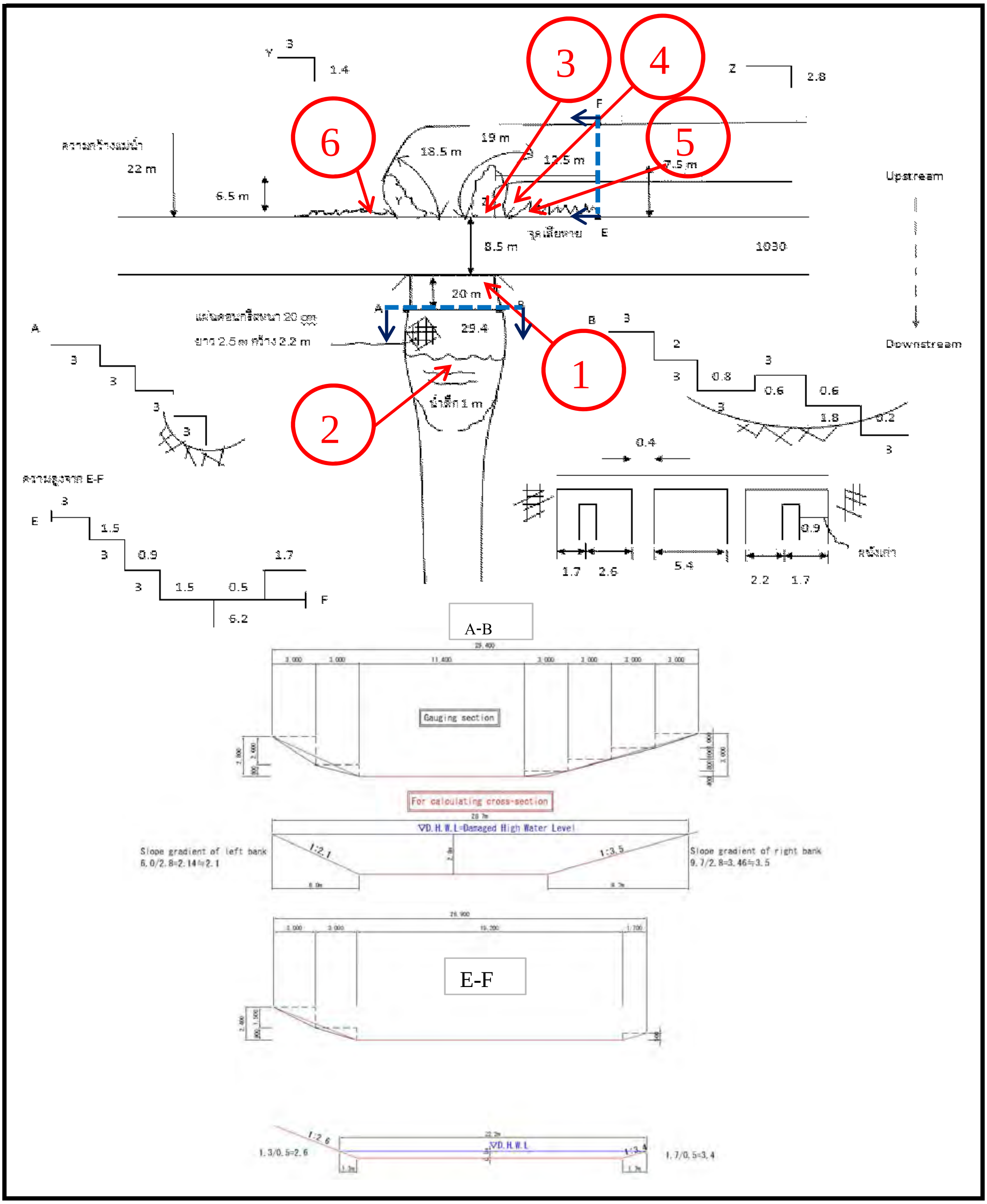
(※at least note upstream and downstream)

↓

Others: write down needed information

Table showing damage restoration (Table A-1)

Bridge Name	Sample (Temporary number : 1030-2)	Inspection Date	26/01/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N 15.076	Province	Lop Buri
Longitude	E 100.675	Main Inspector	(name)



3. 1. 2 Table showing damage pictures (Table A-2)

The documentation of damage pictures is required, so conditions at the actual site are perceived correctly. Moreover, the pictures also illustrate positions and the extent of damages and are used when reviewing decisions and determining the necessity of construction and damage rehabilitation as well as construction and rehabilitation methods. Therefore, damage pictures are required as supplementary information.

When taking pictures, an aim of each picture thereby must be defined so as to know what picture will be taken and think about picture's composition that can show such details precisely and adequately.

General points of consideration when taking pictures are as follows:

- ✓ Plant poles in land survey zone at beginning and ending points so that precise distances can be determined.
- ✓ Be flexible so that cross sectional topography can be examined easily.
- ✓ Note water flow direction, beginning and ending points as well as distances on pictures.
- ✓ Take pictures of structural damages of embankment retaining wall and indicate these damages by using staff or pole, etc.
- ✓ Take pictures of flow directions at upstream and downstream areas, including beginning and end points, so that overall conditions around the bridge can be perceived.

Table showing pictures of damage conditions (Table A-2)

Bridge Name			Inspection Date	
Location			Route Number	
Latitude	N		Province	
Longtitude	E		Main Inspector	

Picture No.	1	Position		Picture No.	2	Position		Picture No.	3	Position	
Description				Description				Description			
Paste picture				Paste picture				Paste picture			
Picture No.	4	Position		Picture No.	5	Position		Picture No.	6	Position	
Description				Description				Description			
Paste picture				Paste picture				Paste picture			

Table showing pictures of damaged conditions (Table A-2)

Bridge Name	Sample (Temporary number : 1030-2)	Inspection Date	26/01/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N 15.076	Province	Lop Buri
Longitude	E 100.675	Main Inspector	(name)

Picture No.	1	Position	Downstream	Picture No.	2	Position	Downstream	Picture No.	3	Position	Under girder
Description	Scour conditions at downstream bank			Description	Conditions of downstream bank			Description	Ruins of pile structure (clogging waterway)		
											

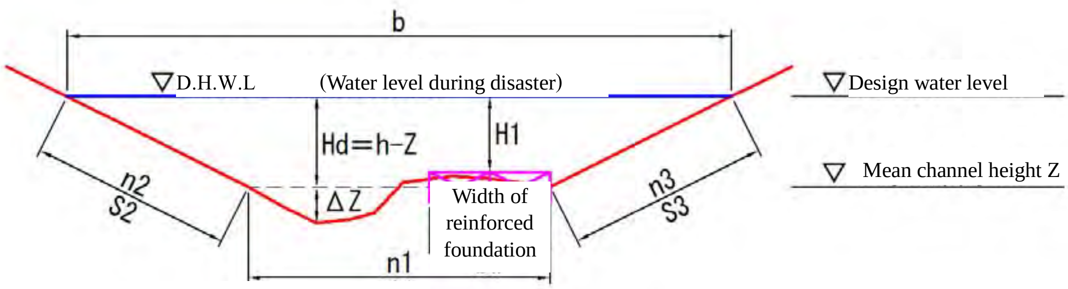
Picture No.	4	Position	Under girder	Picture No.	5	Position	Upstream	Picture No.	6	Position	Road on upstream bank
Description	Scour conditions, depth 2 m			Description	Scour conditions at upstream bank			Description	Damage conditions at top edgeof embankment		
											

3.2 Table for calculating design current velocity (Table B)

Prepare Table B for calculating design current velocity, whereby the objective is to determine embankment.

【Additional chapter】

- ✓ Current velocity is calculated by using the Manning's equation, whereby adjusted coefficient is determined by taking account of topographical conditions and mean current velocity in open water per cross sectional area, in order to choose a suitable embankment construction method.
- ✓ Detailed description of longitudinal slope, roughness coefficient, design water level, mean current velocity, adjusted coefficient, etc. Please refer to the full version of this manual.
- ✓ Since design current velocity derived from the calculation from Table B is not an absolute value, it should be applied by sufficiently taking the actual site and other conditions into consideration.
- ✓ In the abridged manual, only the formula for calculating current velocity per cross section of straight waterway is mentioned. As for the calculation method to obtain current velocity at a bend of a large river, please refer to the full version of this manual.



Determination of roughness coefficient

Roughness coefficient of channel: n1	
Soil type and characteristic	Roughness coefficient
Rock	0.035 ~ 0.050
Large, round stone (10cm~20cm) Gravel	0.030
Pebble (5cm~10cm)	0.035
Sandy soil Sedimentary rock (not over 2cm)	0.020

Roughness coefficient of embankment : n2, n3	
Type of structure	Roughness coefficient
Concrete block	0.024
Wire mesh box	0.032
Grass - approx. height 20cm	0.032
Colored stone - approx. 30cm	0.025

Determination of adjusted coefficient

$\alpha 1$ **If channel is not located where deep excavation exists due to rocks, etc., choose stable channel :**

α 1= 1 If channel has rocks and soil all over, choose unstable channel : α 1= 1 + (△Z/2Hd)

$\alpha 2$ **Select by comparing between bw (width of matting to prevent bank sloping) and H1 (water depth)**

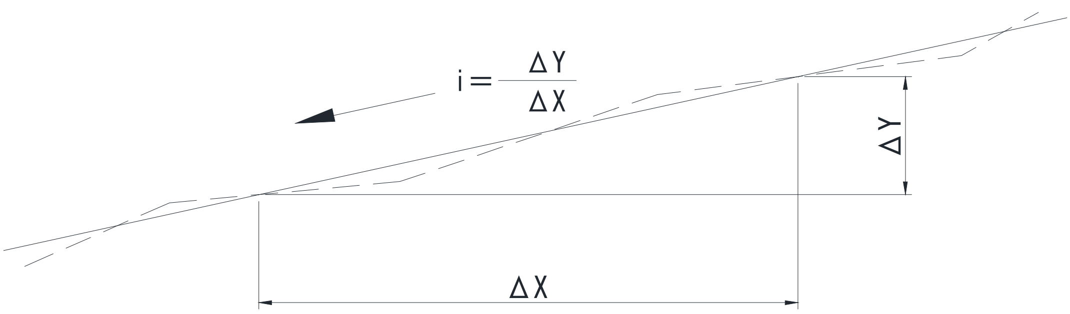
（1）Longitudinal slope

Design current velocity is calculated by using Manning formula. The key point here is setting of longitudinal slope.

When setting the longitudinal slope, it is necessary to set a proper longitudinal slope averaging approximately unevenness of the actual land and according to the height above sea level of the whole water course.

If Irrigation Department or the administrator of the river fix the longitudinal slope, it is necessary to obtain materials about the planned longitudinal slope.

In case any material on the planned longitudinal slope is not available, set a proper longitudinal slope after conducting voluntarily a simple longitudinal measurement.



(Segment-M) $i = \dfrac{\Delta Y}{\Delta X} < \dfrac{1}{60}$

(Segment-1) $i = \dfrac{\Delta Y}{\Delta X} = \dfrac{1}{60} \sim \dfrac{1}{400}$

(Segment-2) $i = \dfrac{\Delta Y}{\Delta X} = \dfrac{1}{400} \sim \dfrac{1}{5,000}$

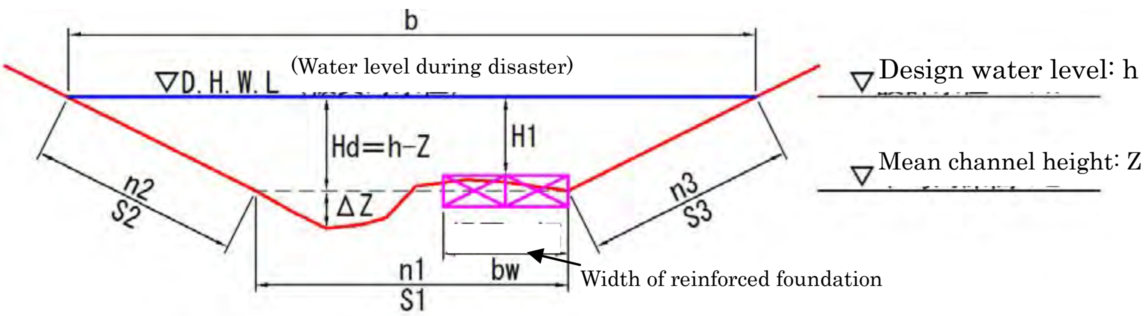
(Segment-3) $i = \dfrac{\Delta Y}{\Delta X} > \dfrac{1}{5,000}$

(2) Roughness coefficient

Set roughness coefficients both for channel part and embankment part (slope part), and combining these two figures to use a total roughness coefficient (N).

$$N = \left[\frac{\sum_{i=1}^{n} \left(n_i^{\frac{3}{2}} \cdot S_i \right)}{S} \right]^{2/3}$$

$$S = S_1 + S_2 + \cdot \cdot \cdot + S_n$$



[Determination of roughness coefficient]

Roughness coefficient of channel: n1

Soil Type	Roughness coefficient
Rock	0. 035～0. 050
Round stone (10cm-20cm)	0. 030
Pebble (5cm-10cm)	0. 035
Sandy soil (not over 2cm)	0. 020

Roughness coefficient of embankment: n2, n3

Type of structure	Roughness coefficient
Concrete block	0. 024
Wire mesh box	0. 032
Grass – approx. height 20cm	0. 032
Round stone – approx.30cm	0. 025

(3) Design water level

Design water level is set as follows.

①If planned high water level is set by Irrigation Department or any administrator of the river neighboring the affected facilities, the design water level shall be planned high water level (HWL).

②If planned high water level is not set, the design water level shall be either the height corresponding to that of crown of existing embankment or the height where the marks of flood remains, whichever is higher.

(4) Mean current velocity

Mean current velocity (Vm) is calculated by using Manning formula.

$$Vm = 1/N \cdot Rd^{2/3} \cdot Ie^{1/2}$$

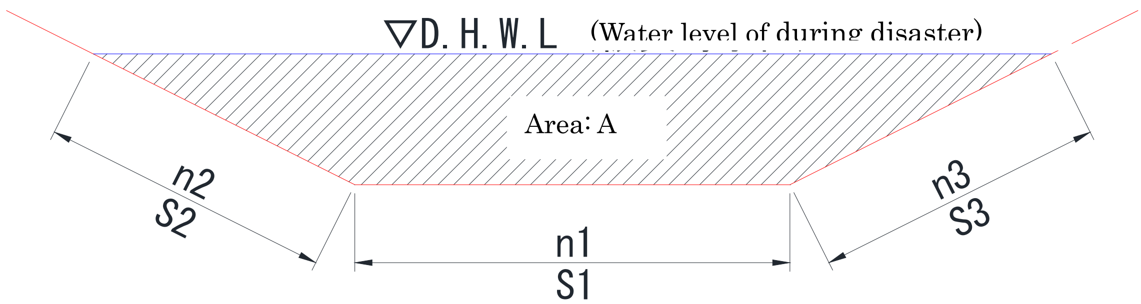
N : Total roughness coefficient

Ie : Incline energy (basically, average slope of channel)

Rd : Hydraulic radius = A/S

A : Cross-sectional area

S : Wetted perimeter $= S_1 + S_2 + S_3$

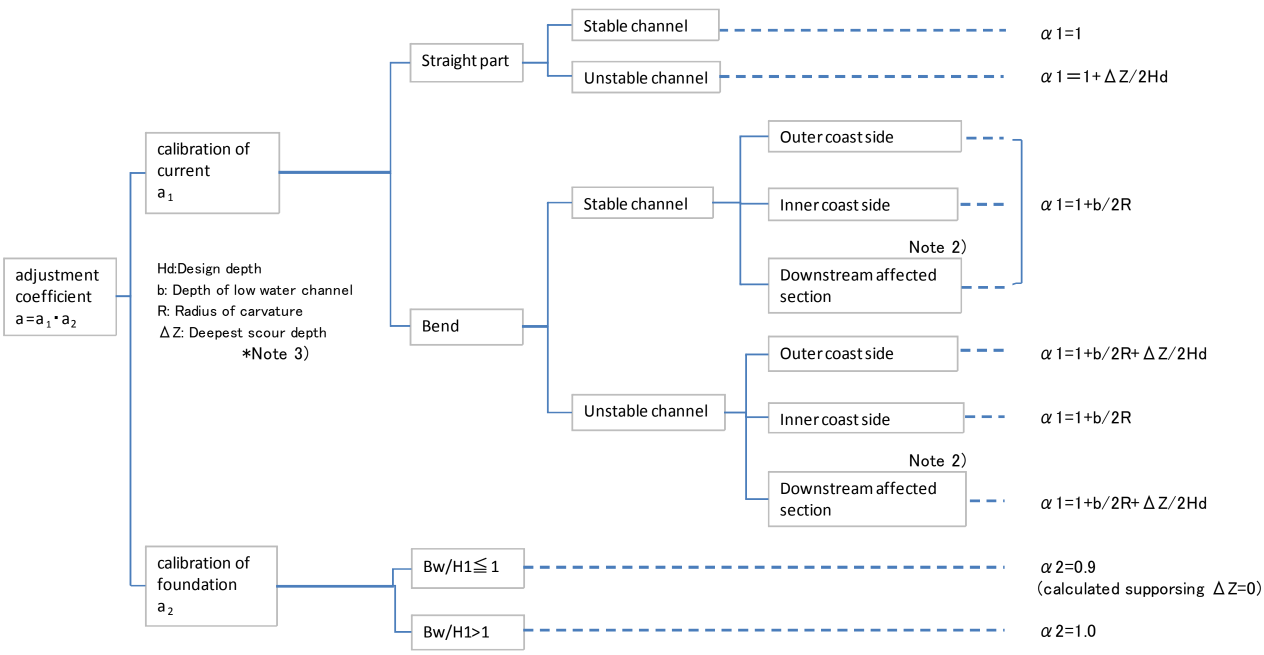


(5) Adjustment coefficient

As for the current velocity used to select the embankment, the cross-sectional mean current velocity calculated by using Manning formula shall be replaced by the local current velocity considering properly the condition of the river, such as the effect of water depth increase due to erosion, or effect of velocity increase due to swirls in bend, which is corrected by adjustment coefficient α.

Adjustment coefficient α is, supposing the calibration of current (α_1) and calibration of reinforced foundation (α_2), calculated as $\alpha = \alpha_1 \cdot \alpha_2$

Calculation flow of this α is shown as follows.



Bw: Reinforced foundation width
H1: Water depth above reinforced foundation

*The upper value of α_1 is 2.

(6) Calculation of current velocity

Mean current velocity (Vm) for the relevant section for calculation is calculated cross-section by cross-section, corrected considering the effects of bend and scouring, to find the principal velocity (V_0) for each cross-section.

Then, averaging these values, design velocity for selecting type of embankment is obtained. However, in case this mean value is not suitable to be applied to rehabilitate the whole distance, type of embankment may be selected setting the principal velocity of each cross-section (V_D) as design velocity.

V_D : Design current velocity

$$V_D = \text{mean}V_0$$

$$\text{mean}V_0 = 1/3(V_1 + V_2 + V_3) \text{ (In case of 3 cross-sections to be examined)}$$

V_1,V_2 and V_3 are the current velocity of each cross-section to be examined

V_0 : Principal velocity (for each cross-section for calculation)

$$V_0 = \alpha \cdot Vm$$

Vm : Mean current velocity of Manning

α : adjustment coefficient (Calibration for bend and scour[α_1]and calibration for reinforced foundation works[α_2])

$$\alpha = \alpha_1 \cdot \alpha_2$$

When mean velocity becomes bigger than maximum velocity ($\sqrt{(gRd)}$), check facilities around upstream/downstream, bend, scour, roughness coefficient, channel slope, etc.

Table for calculating design current velocity (Table B)

【Reviewed position】

Province name	
Road name	
Bridge name	

【Example】

(yellow)	Input number, text
(white)	Input automatic calculation
(red)	Automatically generate review outcome

		Position		No.1	No.2	No.3	Note
River and road		Min waterway width	[b(m)]				
		Longitudinal slope	[Ie]				
		Left bank slope					
		Right bank slope					
Hydraulic radius		Channel radius	[Rd(m)]				
Design water depth		Design water position	[h(m)]				
		Present mean height of water surface	[Z(m)]				
		Design water depth	[Hd(m)]				
Roughness coefficient	Roughness coefficient of each section	Riverbed	[n_1]				
		Left embankment	[n_2]				
		Right embankment	[n_3]				
	Wetted perimeter	Channel	[S_1]				
		Left embankment	[S_2]				
		Right embankment	[S_3]				
		Total	[S]				
	Total roughness coefficient	$\{n_1^{3/2} \times S_1\}$					
		$\{n_2^{3/2} \times S_2\}$					
		$\{n_3^{3/2} \times S_3\}$					
		Total					
		Total roughness coefficient	N				
Mean current velocity [Vm]		$Vm=1/N \cdot Rd^{2/3} \cdot Ie^{1/2}$					
Maximum current velocity [Vc]		$Vc=(g \cdot Rd)^{1/2}$					If Vm>Vc Re-validate factors
Present max scour depth (actual value)			[⊿Z]				
Adjusted coefficient	Stable channel	a1=1					Position where no rock protrudes and excavated channel is deep
	Unstable channel	{⊿Z/2Hd}					
		a1 = 1+{⊿Z/2Hd}					Upper limit 2
	Foundation reinforcement	bw/H1＞1 → α2 = 0.9 bw/H1≦ 1 → α2 = 1.0					Adjusted coefficient in case foundation is reinforced
	α	plied adjusted coefficient a = a1 x					
Principal current velocity [Vo]		$Vo = a \cdot Vm$					
Design current velocity [V_D]		$V_D =$ meanVo					

Table for calculating design current velocity (Table B)

【Reviewed position】

Province name	
Road name	
Bridge name	

【Example】

(yellow)	Input number, text
(white)	Input automatic calculation
(red)	Automatically generate review outcome

		Location		No.1	No.2	No.3	Note
River and road		Min waterway width	[b(m)]	13	13	13	
		Longitudinal slope	[Ie]	1/300	1/300	1/300	
		Left bank slope		2.0	2.0	2.0	
		Right bank slope		2.0	2.0	2.0	
Hydraulic radius		Channel radius	[Rd(m)]	1.3	1.3	1.3	
Design water depth		Design water position	[h(m)]	3.0	3.0	3.0	
		Present mean height of water surface	[Z(m)]	0.9	1.0	1.0	
		Design water depth	[Hd(m)]	2.1	2.0	2.0	
Roughness coefficient	Roughness coefficient of each section	Riverbed	[n_1]	0.030	0.030	0.030	
		Left embankment	[n_2]	0.024	0.032	0.024	
		Right embankment	[n_3]	0.032	0.032	0.032	
	Wetted perimeter	Channel	[S_1]	4.6	5.0	5.0	
		Left embankment	[S_2]	4.7	4.5	4.5	
		Right embankment	[S_3]	4.7	4.5	4.5	
		Total	[S]	14.0	14.0	14.0	
	Total roughness coefficient	$\{n_1^{3/2} \times S_1\}$		0.024	0.026	0.026	
		$\{n_2^{3/2} \times S_2\}$		0.017	0.026	0.017	
		$\{n_3^{3/2} \times S_3\}$		0.027	0.026	0.026	
		Total		0.068	0.078	0.069	
		Total roughness coefficient	N	0.029	0.031	0.029	
Mean current [Vm]		$Vm=1/N \cdot Rd^{2/3} \cdot Ie^{1/2}$		2.4	2.2	2.4	
Maximum current velocity [Vc]		$Vc=(g \cdot Rd)^{1/2}$		3.6	3.6	3.6	If Vm>Vc validation of factors is required
Present max scour depth (actual value)			[⊿Z]	0.5	0.5	0.5	
Adjusted coefficient	Stable channel	a1=1					Position where no rock protrudes and excavated channel is
	Unstable channel	{⊿Z/2Hd}		0.12	0.13	0.13	
		a1 = 1+{⊿Z/2Hd}		1.12	1.13	1.13	Upper limit 2
	Foundation reinforcemen t	bw/H1＞1 → α2 = 0.9 bw/H1≦ 1 → α2 = 1.0		1.00	1.00	1.00	Adjusted coefficient in case foundation is reinforced
	α	plied adjusted coefficient a = a1 x		1.12	1.13	1.13	
Principal [Vo]		V o = a ・ V m		2.7	2.5	2.7	
Design current [V_D]		V_D = meanVo		2.6 (m/s)			

Table for calculating design current velocity (Table B) (Bend)

【Reviewed position】			【Example】	
Province name				Input number, text
Road name				Output automatic calculation
Bridge name				utomatically generate review outcom

					No.1	No.2	No.3	Note
River and road			Position					
			Min waterway width	[b(m)]				
			Radius of curvature (center of river cours	[R(m)]				
			Radius of bend (inner coast side)	[r(m)]				
			Longitudinal slope	[Ie]				
			Left bank slope					
			Right bank slope					
Hydraulic			Channel radius	[Rd(m)]				
Design water depth			Design water position	[h(m)]				
			Present mean height of water surface	[Z(m)]				
			Design water depth	[Hd(m)]				
Rouhgness coefficient	Roughness coefficient of each		Riverbed	[n_1]				
			Left embankment	[n_2]				
			Right embankment	[n_3]				
	Wetted perimeter		Channel	[S_1]				
			Left embankment	[S_2]				
			Right embankment	[S_3]				
			Total	[S]				
	Total roughness coefficient		$\{n_1^{3/2} \times S_1\}$					
			$\{n_2^{3/2} \times S_2\}$					
			$\{n_3^{3/2} \times S_3\}$					
			Total					
			Total roughness coefficient	N				
Mean current velocity [Vm]			$Vm=1/N \cdot Rd^{2/3} \cdot Ie^{1/2}$					
Max. current velocity [Vc]			$Vc=(g \cdot Rd)^{1/2}$					If Vm>Vc, re-validate factors
Present max scour depth (actual value)				[ΔZ]				
Adjustment coefficient	Stable channel		{b/2R}					Downstream sideL=5b section
			α1＝1+{b/2R}					
	Unstable channel	Outer coast	{ΔZ/2Hd}					
			{b/2R}					
			α1＝1+{b/2R}+{ΔZ/2Hd}					Upper limit=2
		Inner coast	{b/2R}					
			α1=1+{b/2R}					
		Affected part	{ΔZ/2Hd}					Downstream sideL=2b section
			{b/2R}					
			α1＝1+{b/2R}+{ΔZ/2Hd}					Upper limit=2
	Foundation reinforceme		bw/H1＞1 → α2＝0.9 bw/H1≦1 → α2＝1.0					adjustment coefficient in case foundation is reinforced
	α		Applied adjustment coefficientα＝α1×α2					
Principal current velocity [Vo]			Vo＝α・Vm					
Design current velocity			V_D＝ meanVo					

Table for calculating design current velocity (Table B) (Bend)

【Reviewed position】

Province name	
Road name	
Bridge name	

【Example】

(yellow)	Input number, text
(white)	Output automatic calculation
(pink)	utomatically generate review outcom

				No.1	No.2	No.3	Note
River and road		Position		No.1	No.2	No.3	Note
		Min waterway width	[b(m)]	13	13	13	
		Radius of curvature (center of river cours	[R(m)]	50	50	50	
		Radius of bend (inner coast side)	[r(m)]	44	44	44	
		Longitudinal slope	[Ie]	1/300	1/300	1/300	
		Left bank slope		2. 0	2. 0	2. 0	
		Right bank slope		2. 0	2. 0	2. 0	
Hydraulic		Channel radius	[Rd(m)]	1. 3	1. 3	1. 3	
Design water depth		Design water position	[h(m)]	3. 0	3. 0	3. 0	
		Present mean height of water surface	[Z(m)]	0. 9	1. 0	1. 0	
		Design water depth	[Hd(m)]	2. 1	2. 0	2. 0	
Rouhgness coefficient	Roughness coefficient of each	Riverbed	[n_1]	0. 030	0. 030	0. 030	
		Left embankment	[n_2]	0. 024	0. 032	0. 024	
		Right embankment	[n_3]	0. 032	0. 032	0. 032	
	Wetted perimeter	Channel	[S_1]	4. 6	5. 0	5. 0	
		Left embankment	[S_2]	4. 7	4. 5	4. 5	
		Right embankment	[S_3]	4. 7	4. 5	4. 5	
		Total	[S]	14. 0	14. 0	14. 0	
	Total roughness coefficient	$\{n_1^{3/2}\times S_1\}$		0. 024	0. 026	0. 026	
		$\{n_2^{3/2}\times S_2\}$		0. 017	0. 026	0. 017	
		$\{n_3^{3/2}\times S_3\}$		0. 027	0. 026	0. 026	
		Total		0. 068	0. 078	0. 069	
		Total roughness coefficient	N	0. 029	0. 031	0. 029	
Mean current velocity [Vm]		$Vm=1/N\cdot Rd^{2/3}\cdot Ie^{1/2}$		2. 4	2. 2	2. 4	
Max. current velocity [Vc]		$Vc=(g\cdot Rd)^{1/2}$		3. 6	3. 6	3. 6	If Vm>Vc, re-validate factors
Present max scour depth (actual value)			[ΔZ]	0. 5	0. 5	0. 5	
Adjustment coefficient	Stable channel	{b/2R}					Downstream sideL=5b section
		α1＝1+{b/2R}					
	Unstable channel — Outer coast	{ΔZ/2Hd}		0. 12	0. 13	0. 13	
		{b/2R}		0. 13	0. 13	0. 13	
		α1＝1+{b/2R}+{ΔZ/2Hd}		1. 25	1. 26	1. 26	Upper limit=2
	Unstable channel — Inner coast	{b/2R}					
		α1=1+{b/2R}					
	Unstable channel — Affected part	{ΔZ/2Hd}					Downstream sideL=2b section
		{b/2R}					
		α1＝1+{b/2R}+{ΔZ/2Hd}					Upper limit=2
	Foundation reinforceme	bw/H1＞１ → α2=0.9 bw/H1≦１ → α2=1.0		1. 00	1. 00	1. 00	adjustment coefficient in case foundation is reinforced
	α	Applied adjustment coefficientα＝α1×α2		1. 25	1. 26	1. 26	
Principal current velocity [Vo]		Ｖｏ＝α ・ Ｖｍ		3. 0	2. 8	3. 0	
Design current velocity		V_D = meanVo		2. 9 (m/s)			

Chapter 4 Flood Disaster Measures and Rehabilitation Design

This Chapter explains the method of designing measures to prevent flood damage, and the method of designing post-flood rehabilitation plans.

4.1 Design of Slope Protective Works

(1)Types and characteristics of slope protective works

When selecting slope protection method, it is necessary to understand well the characteristics of each method, since structure, material used and appearance are different.

＜＜Explanation＞＞

1) As for slope protective works, it is important to investigate the structure of damaged facilities and the condition of external force that influenced so as to utilize in design, and referring to samples of damage in the past or in similar rivers, it is required to understand the structural characteristics of each slope protection method so that the best method is selected according to the river attributes of the place.

2) As reference when designing, slope protective works generally performed sorted by methods of construction and materials and its characteristics and main attributes against the environment are shown in Table C and Table D.

3) As the attributes of slope protective works differ greatly depending on the types and materials/shapes, follow-up surveys shall be constantly conducted even after the completion of construction.

(2)Basic Idea when selecting a slope protective work

A slope protective work is selected, considering comprehensively external force such as design current velocity of the relevant place, damage condition, cause, scale of river, condition of floodway, condition of hinterland, environment of the river, shape of cross-section, as well as durability of materials, economical efficiency, constraints of construction.

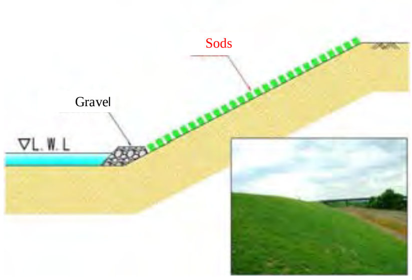
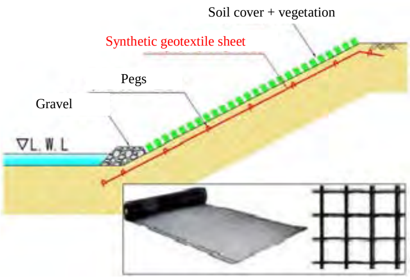
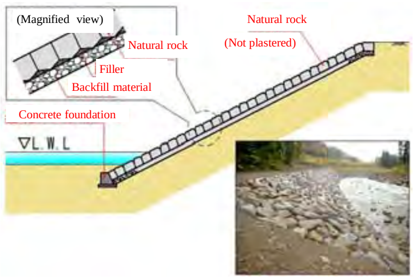
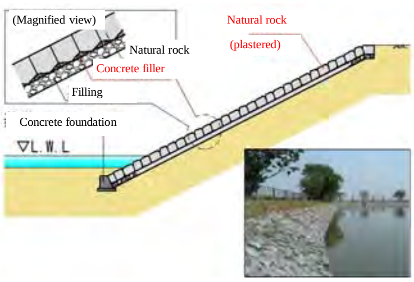
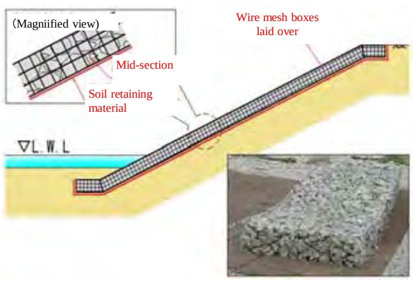
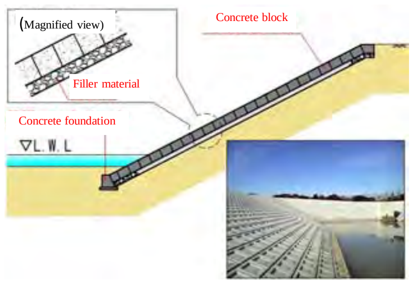
＜＜Explanation＞＞

1) Standard design current velocity corresponding to each method of slope protective works is shown in the correlation tables of embankment and design current velocity (Table C and Table D). Its range of application is a reference value, for the moment, deduced from the experiences of construction works and not yet proved by experiments. When applying practically, attributes of each river shall be sufficiently taken into consideration.

2) Even being within the range of applied velocity, attention to be paid to some methods of construction in which, over time, the material used is deteriorated and stability is lost. In selecting the material, cause of damage, external force of design, consideration of surrounding environment, durability, maintenance and management, condition of hinterland, scale of river shall be taken into account.

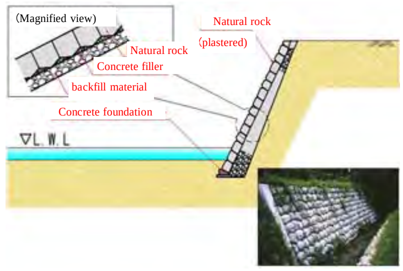
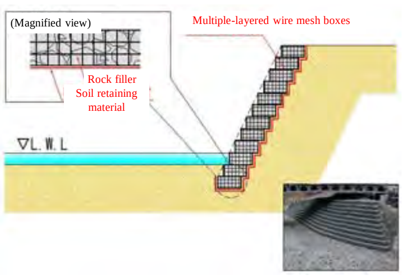
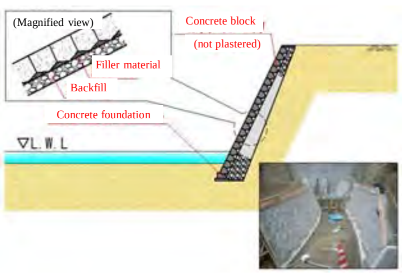
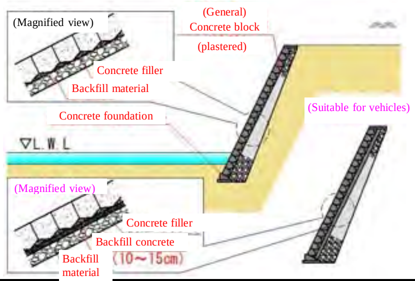
3) When the slope ratio of embankment is less than 1:1.5, a construction method applicable is selected from Table C. When the slope ratio of embankment is greater than 1:1.5, a construction method applicable is selected from Table D.

Construction method where slope ratio is less than 1:1.5 (Table C)

Designation of embankment construction method			Graphic overview	Design current velocity (m/s)					Plantable or not	Unit construction cost (yen/m^2)
				2	3	4	5	6		
Vegetation	C-1	Sodding							○	900
Sheeting	C-2	Synthetic geotextile sheet							○	2,500
Rock	C-3	Natural rock (not plastered with cement)							Δ̸	9,900
	C-4	Natural rock (plastered with cement)							Δ̸	16,200
Wire mesh box	C-5	Wire mesh box							○	11,000
Concrete	C-6	Concrete block							Δ̸	13,300

○ = Plantable Δ̸ = Not plantable

Construction method where slope ratio is greater than 1:1.5 (Table D)

Designation of construction method for retaining wall			Graphic overview	Design current velocity (m/s) 2	3	4	5	6	For vegetation	Unit construction cost (yen/m^2)
Rock	D-1	Natural rock (plastered with cement)							△	16,200
Wire mesh box	D-2	Multiple-layered wire mesh boxes							○	13,500
Concrete	D-3	Concrete block (not plastered with cement)							△	15,400
	D-4	Concrete block (plastered with cement)							△	21,700

○ = Plantable △ = Note plantable

Standard drawings of construction method in Table C and Table D are shown in this Chapter.

Construction method where slope ratio is less than 1:1.5 (Table C)

Designation of Method		Ref.page
C-1	Sodding	p.64
C-2	Synthetic geotextile sheet	p.65
C-3	Natural rock(not plastered with cement)	p.66
C-4	Natural rock(plastered with cement)	p.67
C-5	Wire mesh box	p.68
C-6	Concrete block	p.69

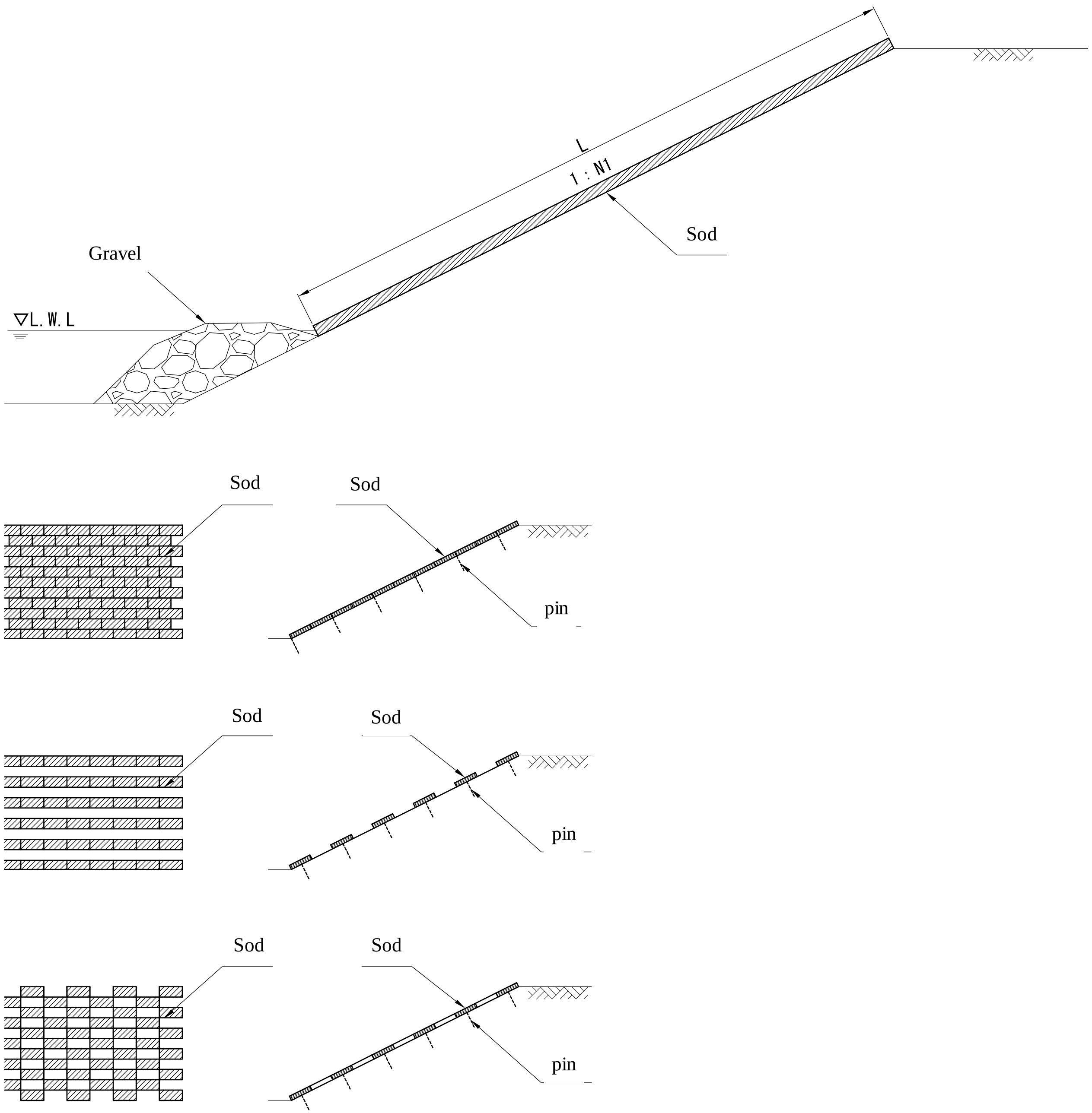
Construction method where slope ratio is greater than 1:1.5 (Table D)

Designation of Method		Ref.page
D-1	Natural rock (plastered with cement)	p.70
D-2	Multiple-layered wire mesh boxes	p.71
D-3	Concrete block (not plastered with cement)	p.72
D-4	Concrete block (plastered with cement)	p.73

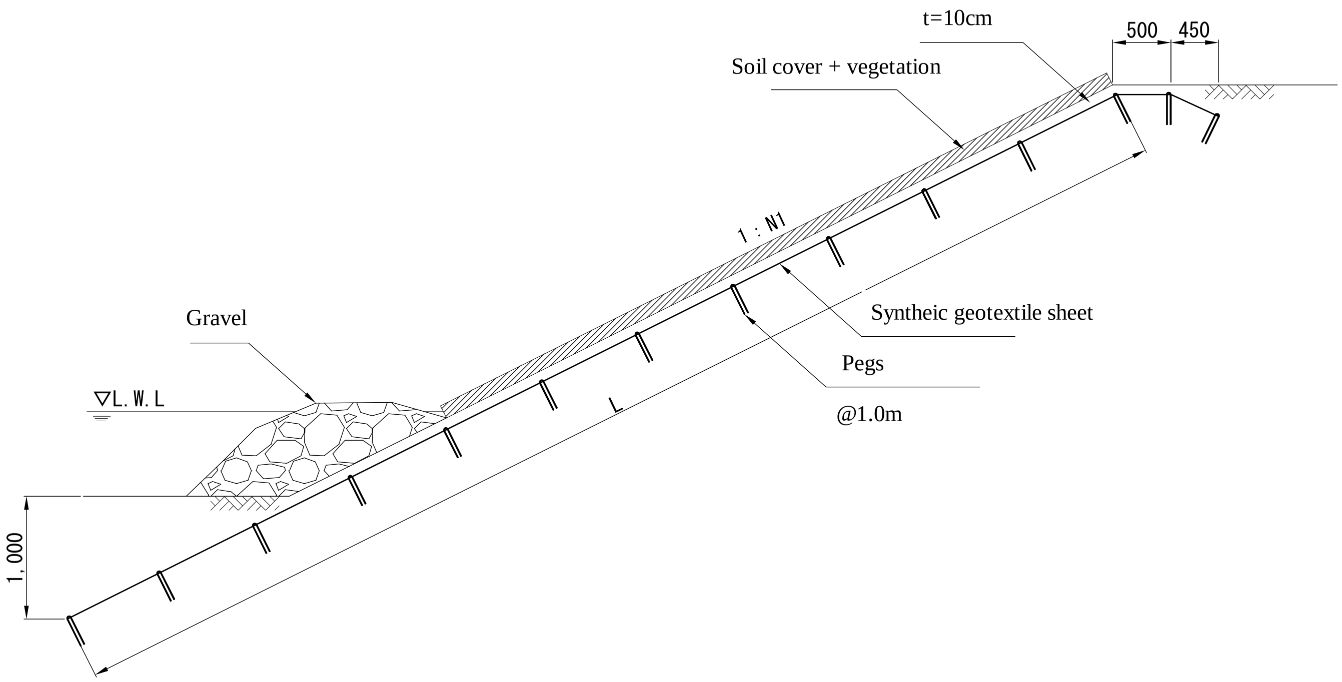
【Supplementary Explanation】

- ✓ Ensure depth of embedment “h” of the crown of foundation in the rehabilitation construction to be 0.5(m)～1.5(m).
- ✓ Depth of embedment “h” shall be fixed according to the judgment of engineers, after comprehensively confirming scale of river, flow channel geometry, scouring condition, material of riverbed, cause of damage, condition of embedment of upstream/downstream structures.

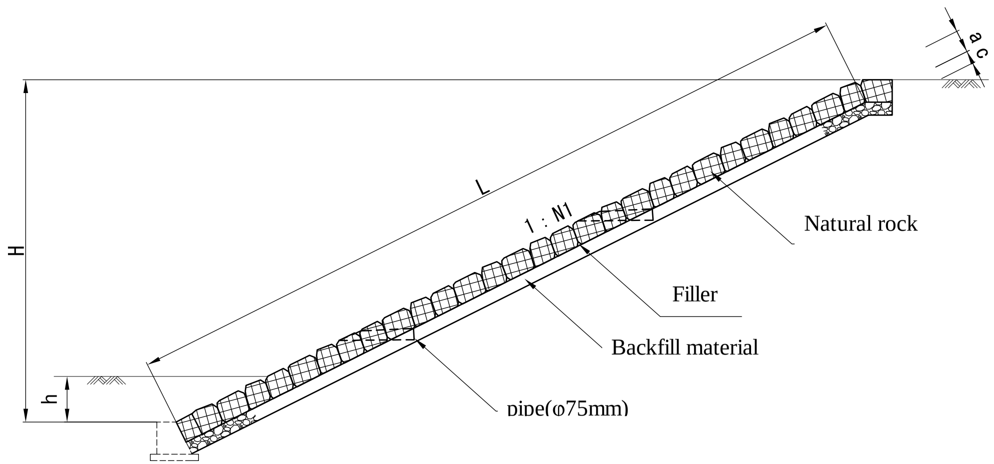
【C-1】Sodding



【C-2】 Geotextile

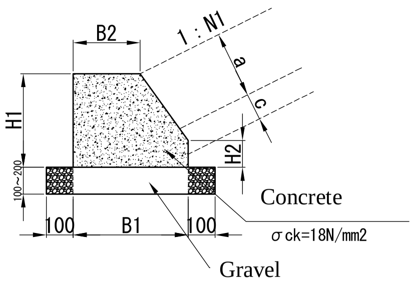


【C−3】 Natural rock(not plastered with cement)



(mm)

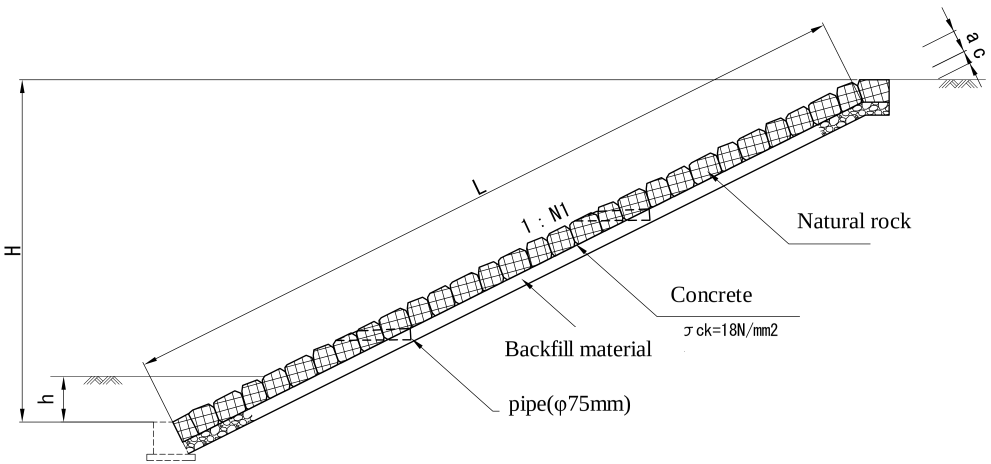
H	L				
	N1				
(m)	1:1.0	1:1.5	1:2.0	a	c
1.00	1414	1803	2236	350	200
2.00	2828	3606	4472	350	200
3.00	4242	5409	6708	350	200
4.00	5656	7212	8944	350	200
5.00	7070	9015	11180	350	200



(mm)

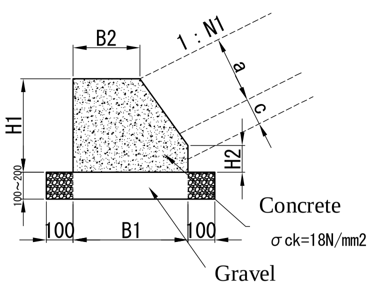
	B1	B2	H1	H2
1:1.0	700	300	500	100
1:1.5	560	300	500	100
1:2.0	550	300	500	0

【C-4】 Natural rock(plastered with cement)



(mm)

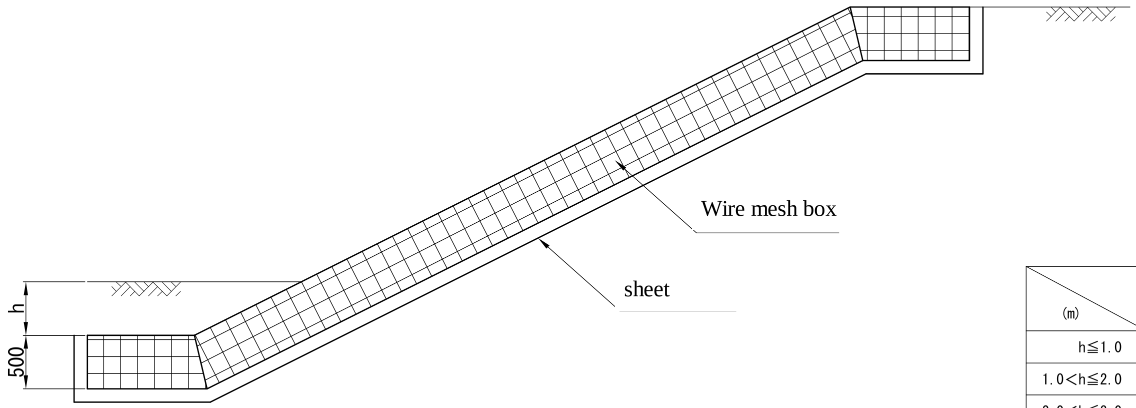
H	L				
	N1				
(m)	1:1.0	1:1.5	1:2.0	a	c
1.00	1414	1803	2236	350	200
2.00	2828	3606	4472	350	200
3.00	4242	5409	6708	350	200
4.00	5656	7212	8944	350	200
5.00	7070	9015	11180	350	200



(mm)

	B1	B2	H1	H2
1:1.0	700	300	500	100
1:1.5	560	300	500	100
1:2.0	550	300	500	0

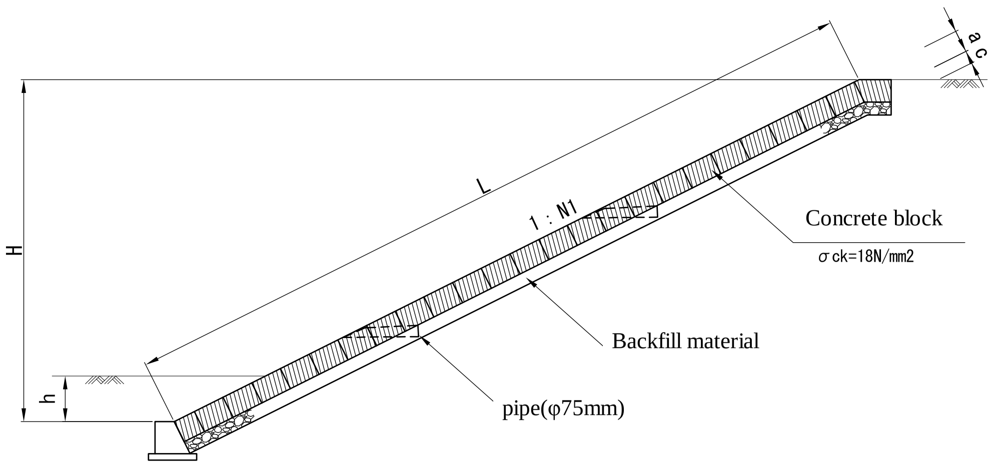
【C−5】Wire mesh box



(cm)

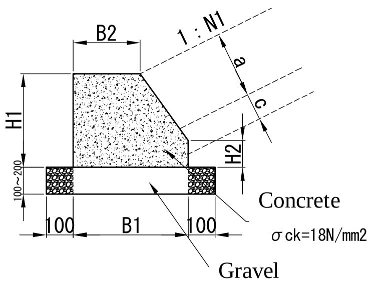
(m)	(m/s)						
	1.0	2.0	3.0	4.0	5.0	6.0	6.5
h≦1.0	5～15	5～15	5～15	5～15	15～20	—	—
1.0<h≦2.0	5～15	5～15	5～15	5～15	5～15	15～20	15～20
2.0<h≦3.0	5～15	5～15	5～15	5～15	5～15	5～15	15～20
3.0<h≦4.0	5～15	5～15	5～15	5～15	5～15	5～15	5～15
4.0<h≦5.0	5～15	5～15	5～15	5～15	5～15	5～15	5～15

【C-6】 Concrete block



(mm)

H (m)	L N1 1:1.0	L N1 1:1.5	L N1 1:2.0	a	c
1.00	1414	1803	2236	350	200
2.00	2828	3606	4472	350	200
3.00	4242	5409	6708	350	200
4.00	5656	7212	8944	350	200
5.00	7070	9015	11180	350	200



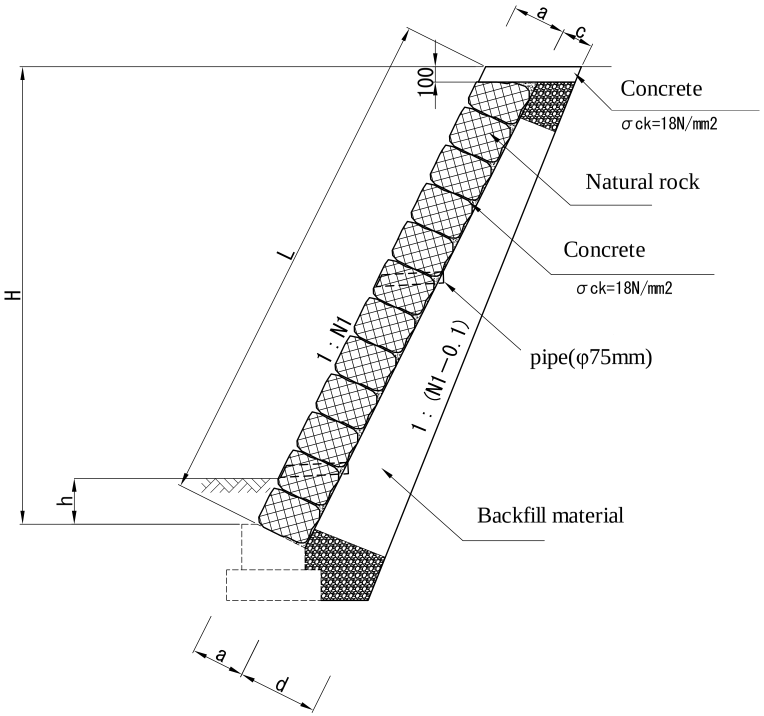
(mm)

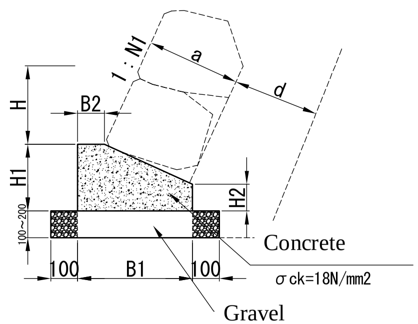
	B1	B2	H1	H2
1:1.0	700	300	500	100
1:1.5	560	300	500	100
1:2.0	550	300	500	0

【D-1】 Natural rock(plastered with cement)

(mm)

H	L				(mm)							
	N1				U1				U2			
(m)	1:0.3	1:0.4	1:0.5	a	c	d 1:0.3	d 1:0.4	d 1:0.5	c	d 1:0.3	d 1:0.4	d 1:0.5
1.00	1044	1077	1118	350	200	339	335	300	300	439	435	430
1.50	1566	1616	1677	350	200	387	381	374	300	487	481	474
2.00	—	2154	2236	350	200	—	427	419	300	—	527	519
2.50	—	2693	2795	350	200	—	474	454	300	—	574	564
3.00	—	3231	3354	350	200	—	520	509	300	—	620	609
3.50	—	—	3913	350	200	—	—	553	300	—	—	653
4.00	—	—	4473	350	200	—	—	598	300	—	—	698
4.50	—	—	5031	350	200	—	—	643	300	—	—	743
5.00	—	—	5590	350	200	—	—	687	300	—	—	787

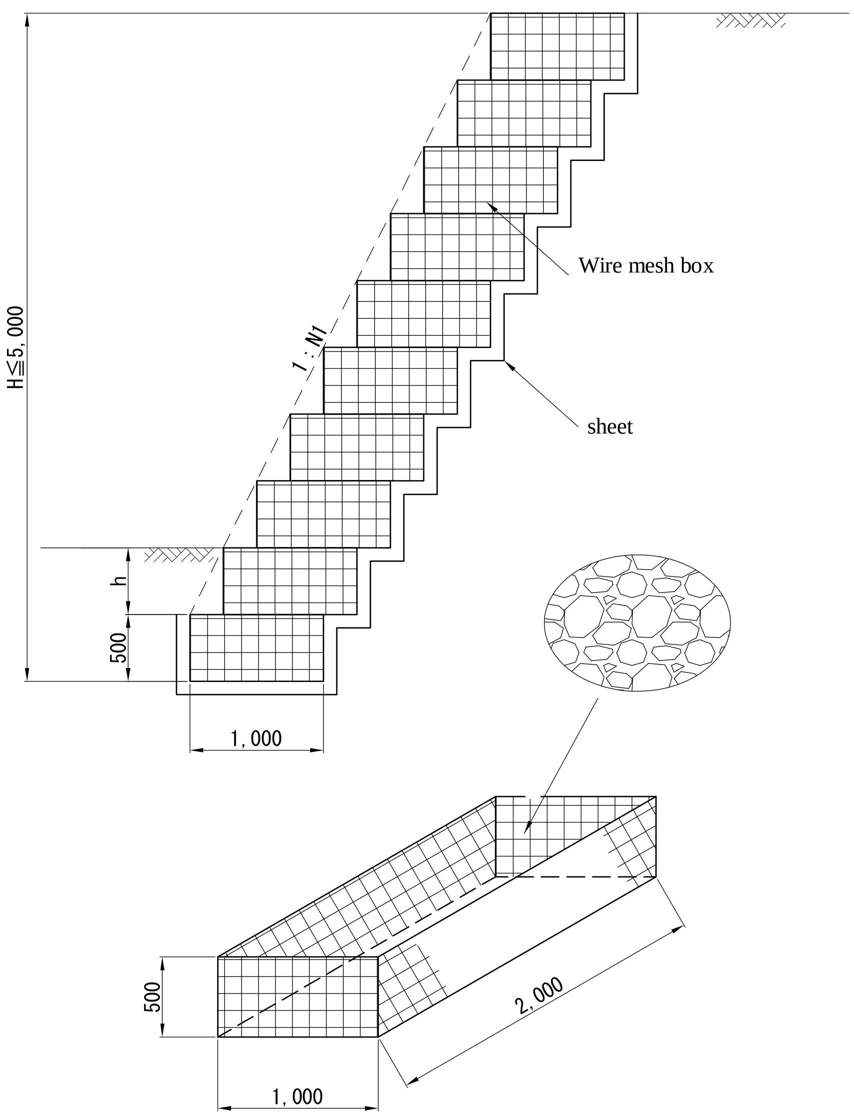




(mm)

a	B1	B2	H1	H2
350	430	100	250	100

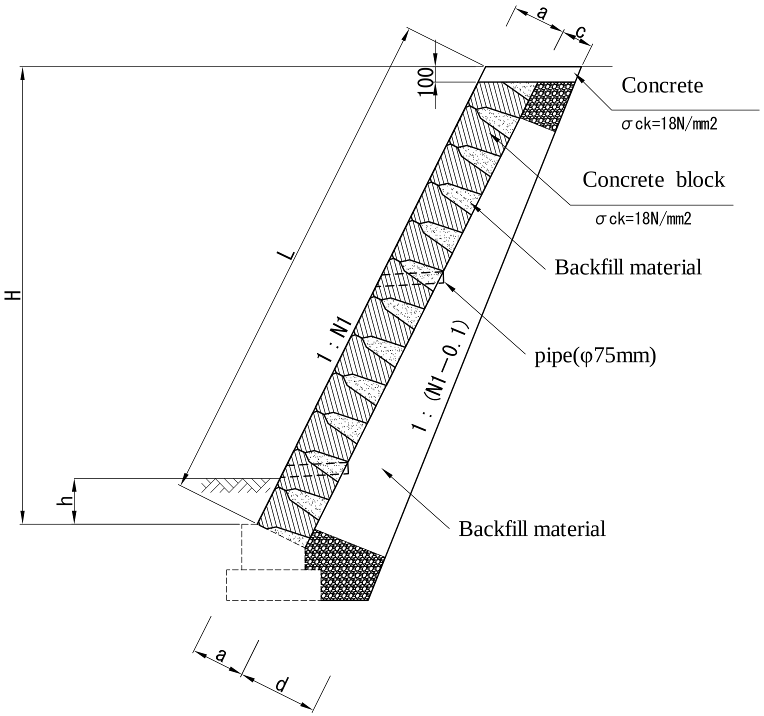
【D-2】Multiple-layered wire mesh boxes



(cm)

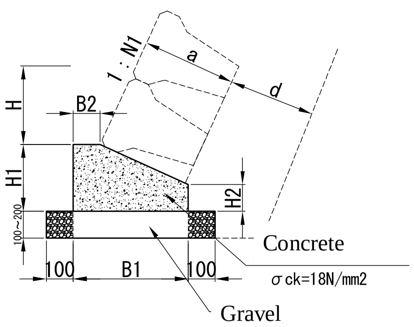
(m)	(m/s) 1.0	2.0	3.0	4.0	5.0	6.0	6.5
h≦1.0	5～15	5～15	5～15	5～15	15～20	—	—
1.0<h≦2.0	5～15	5～15	5～15	5～15	5～15	15～20	15～20
2.0<h≦3.0	5～15	5～15	5～15	5～15	5～15	5～15	15～20
3.0<h≦4.0	5～15	5～15	5～15	5～15	5～15	5～15	5～15
4.0<h≦5.0	5～15	5～15	5～15	5～15	5～15	5～15	5～15

【D−3】 Concrete block(not plastered with cement)



(mm)

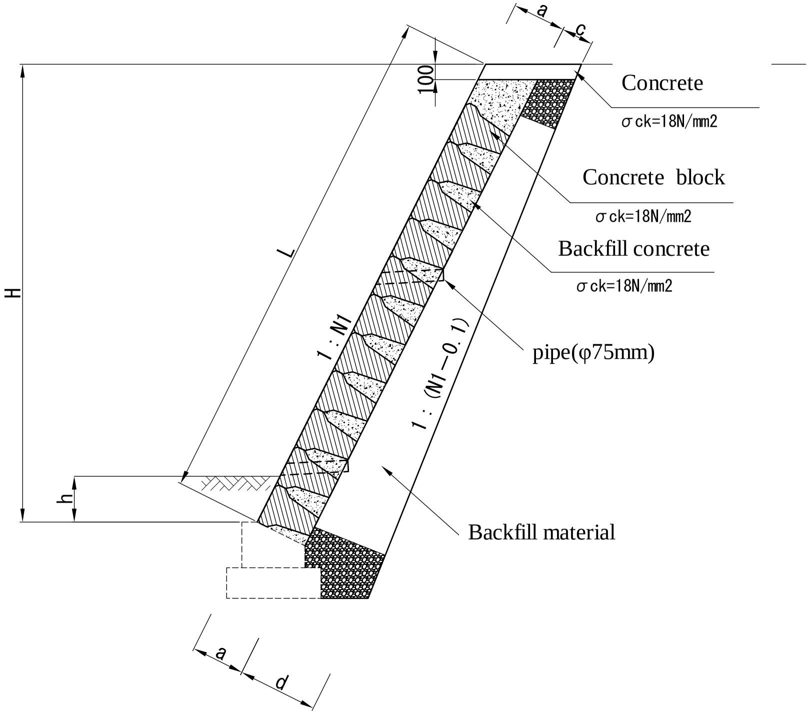
H	L											
	N1				U1				U2			
				a	c	d			c	d		
(m)	1:0.3	1:0.4	1:0.5			1:0.3	1:0.4	1:0.5		1:0.3	1:0.4	1:0.5
1.00	1044	1077	1118	350	200	339	335	300	300	439	435	430
1.50	1566	1616	1677	350	200	387	381	374	300	487	481	474
2.00	—	2154	2236	350	200	—	427	419	300	—	527	519
2.50	—	2693	2795	350	200	—	474	454	300	—	574	564
3.00	—	3231	3354	350	200	—	520	509	300	—	620	609
3.50	—	—	3913	350	200	—	—	553	300	—	—	653
4.00	—	—	4473	350	200	—	—	598	300	—	—	698
4.50	—	—	5031	350	200	—	—	643	300	—	—	743
5.00	—	—	5590	350	200	—	—	687	300	—	—	787



(mm)

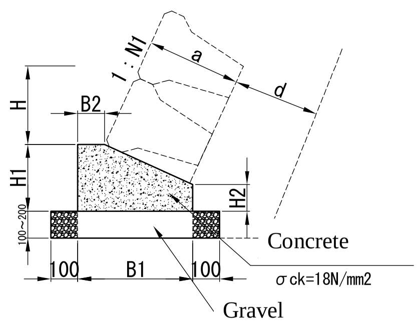
a	B1	B2	H1	H2
350	430	100	250	100

【D-4】 Concrete block(plastered with cement)



(mm)

H (m)	L N1 1:0.3	L N1 1:0.4	L N1 1:0.5	a	U1 c	U1 d 1:0.3	U1 d 1:0.4	U1 d 1:0.5	U2 c	U2 d 1:0.3	U2 d 1:0.4	U2 d 1:0.5
1.00	1044	1077	1118	350	200	339	335	300	300	439	435	430
1.50	1566	1616	1677	350	200	387	381	374	300	487	481	474
2.00	—	2154	2236	350	200	—	427	419	300	—	527	519
2.50	—	2693	2795	350	200	—	474	454	300	—	574	564
3.00	—	3231	3354	350	200	—	520	509	300	—	620	609
3.50	—	—	3913	350	200	—	—	553	300	—	—	653
4.00	—	—	4473	350	200	—	—	598	300	—	—	698
4.50	—	—	5031	350	200	—	—	643	300	—	—	743
5.00	—	—	5590	350	200	—	—	687	300	—	—	787



(mm)

a	B1	B2	H1	H2
350	430	100	250	100

4.2 Design of Foundation Works

Foundation works (foot protection works), whose crown height of the foundation is fixed considering scouring due to floods, shall have a structure that holds the slope protection safe.

When back filling the foundation, the river environment shall be taken into account, by diversifying riparian area with gravel, etc.

＜＜Explanation＞＞

1) The most remarkable case of the damage to embankment is that the foundation and slope protection are damaged because the foundation comes to surface due to the scouring during floods.

2) Basic ideas of the crown of foundation work are as follows.

①The crown height of foundation work is generally embedded by 0.5m-1.5m from the present deepest height of riverbed or estimate deepest depth of scour, whose depth of embedment is fixed considering scale of river, scouring condition, current velocity, whether it is water colliding front or not, material of riverbed, cause of damage and depth of embedment of upstream/downstream structures.

②For the places where scouring in the riverbed is big or local scouring is assumed, if stability is not achieved only by the embedment of the foundation or it is more economical than ensuring length of embedment of the foundation, necessity of reinforced foundation is considered.

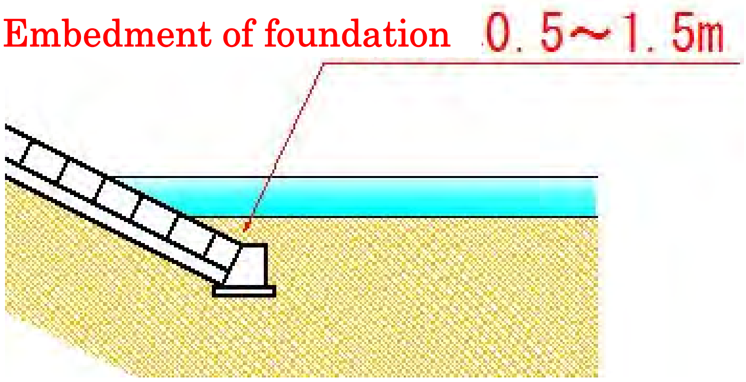


Image4.2.1　Graphic outline of embedment of the foundation

4.3 Design of Foundation Reinforcement Works

A reinforced foundation is established to buffer scouring during flood and hold the foundation work stable, and performed separately or in combination with slope protective works.

As there are methods of foundation reinforcement works with various materials, it is necessary to fully understand the characteristics of each method of construction.

＜＜Explanation＞＞

1) Most of the causes of the damage to embankment are due to scouring of the foundation. Foundation reinforcement works are performed for the purpose of reducing force of flow in that point and buffering rapid scouring by covering directly the riverbed.
2) Foundation reinforcement works need to be safe against force of water flow. Therefore, its type and arrangement is examined based on the knowledge of structural characteristics, in the same way as the case of slope protective work.
3) In the light of efficient use of resources and environmental conservation, it is strongly recommended to utilize wood generated in the actual site or lumber from thinning.
4) Table 4.3.1 shows the types of foundation reinforcement works generally performed.

(2)Basic Idea when Selecting Foundation Reinforcement Method

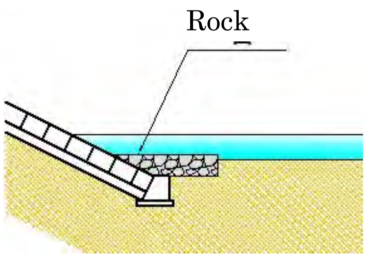
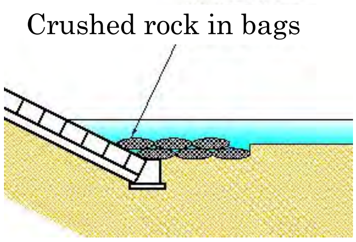
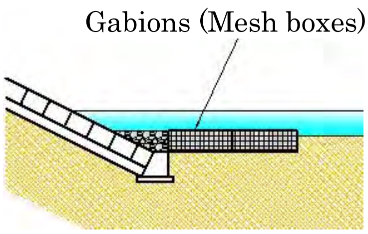
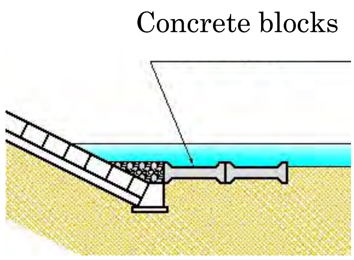
Foundation reinforcement works should be structurally safe against external force such as design current velocity according to damage condition and the river attributes and selected paying attention to the river environment and considering comprehensively workability and economy.

＜＜Explanation＞＞

1) Foundation reinforcement method is adopted corresponding to the design current velocity, which is an external force.　Also, references to history of past works should be taken into account when designing.

2) Even if it is a method not written in Table 4.3.1, any method may be adopted as long as reasonable reinforcement structure adaptable to design current velocity is realized.

Table 4.3.1 Types and characteristics of reinforced foundation

	Graphic overview	Characteristics and basic ideas
Rock		・ The diameter of rock is properly selected so as to resist the current velocity. ・ Utilize stone and rock near the actual site.
Bag		・In case of high velocity, the bags should be bound together by wire, etc. ・Be careful not to damage the bags with sharp/pointed fillings.
Gabion		・Material of the mesh boxes to be used should have enough strength and durability. ・Be sure not to use in the water course where big boulders flow.
Block		・Those with proper weight and safety against hydrodynamic force shall be adopted. ・In case of high current velocity, bind the blocks.

(3) Points of Attention when Performing Foundation Reinforcement Works

Foundation Reinforcement Works are performed basically in the following cases, considering design current velocity and change in riverbed, such as local scouring to riverbed.

- In case where the cause of damage is scouring. Or reinforced foundation is flown out.
- In case where the deepest riverbed is deep and embedment of the foundation of revetment is not economical.
- In case where necessary stability cannot be assured only by embedment of foundation.

＜＜Explanation＞＞

1) Foundation reinforcement works are performed in a right place, grasping cause of damage enough. In such place where is damaged due to rapid scouring in riverbed when flooding, where is easily damaged due to local scouring such as water colliding front, or where there are existing reinforced foundations (including upstream and downstream), conditions of the actual site should be grasped enough to perform the work, considering the necessity.

2) When performing the foundation reinforcement works, take care of the preservation of various environments around water colliding front.

3) As for the height of reinforced foundation, in principle, the top face of the reinforced foundation should be the same level as the present riverbed height where the reinforced foundation is being placed. However, if it is not adequate considering water depth of the point where the reinforced foundation is being placed, conditions of upstream/downstream riverbed, etc., the height of reinforced foundation may be changed.

4.4 Crown works, Crown protective works, Side Protective Works, Transition Works, etc.

> Crown works and crown protective works are performed to protect the top surface of slope protection. Transition works are performed to protect the upstream/downstream transitions from erosion.

＜＜Explanation＞＞

1) Depending on the topography of the place where revetment is constructed, relation to the upstream/downstream facilities, or nature of the soil, etc., auxiliary constructions, such as crown works/crown protective works, side edges protective works, material to prevent soil draw-out, backfilling material, transition works, etc. are required properly as needed.

2) If such auxiliary construction is designed inadequately, there are many cases that such poor design lead erosion from top surface or upstream/ downstream sides or soil draw-out from backside resulting in damage to revetment.

Table4.4.1 Types and characteristics of crown protective works

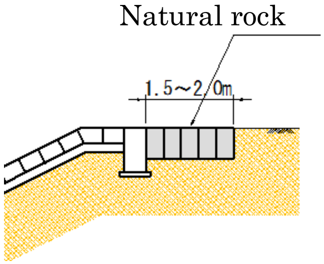
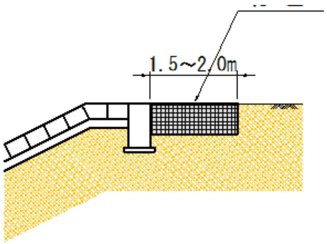
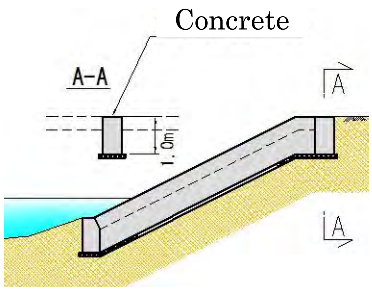
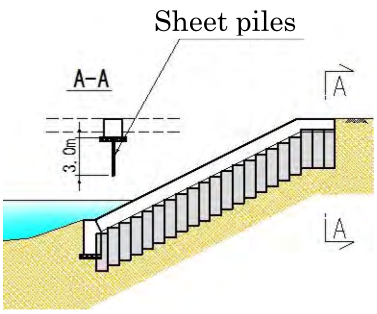
	Graphic overview	Characteristics and basic ideas
Rock		・Generally, the width of construction is 1.5m-2.0m. ・Utilize stone and rock around the actual site.
Gabion		・Generally, the width of construction is 1.5m-2.0m. ・Utilize stone and rock around the actual site for filling.

Table4.4.2 Types and characteristics of side protection works

	Graphic overview	Characteristics and basic ideas
Concrete		・Concrete walls of about 1.0m height are placed at the upstream and downstream side edges of the revetment.
Sheet pile		・Sheet piles of about 3.0m height are placed at the upstream and downstream edges of the revetment.

4.5　Design of Groins

Slope protection and foot protection are mainly used as methods of protecting embankment from erosion.　However, if the river is wide and changing water flow direction is expected to protect embankment from erosion, construction of groins may be also considered.

＜＜Explanation＞＞

1) The effects of groin are listed as follows, which should be taken advantage after examining conditions of application, such as scale of river, slope, etc. before applying.

①Groin is likely to let earth and soil pile up around it, which is expected to help reduce current velocity.

②To change water flow direction.　To create variable water front lines and good landscapes

2) For rivers with width (HWL width) over 25m, consider whether groin can be adopted or not.

3) For rivers with narrower width than the above, placement of groin can foster scour in riverbed or erosion of banks.　Therefore, full consideration is required to judge the adoption, taking the past history of the relevant river and similar rivers into account.

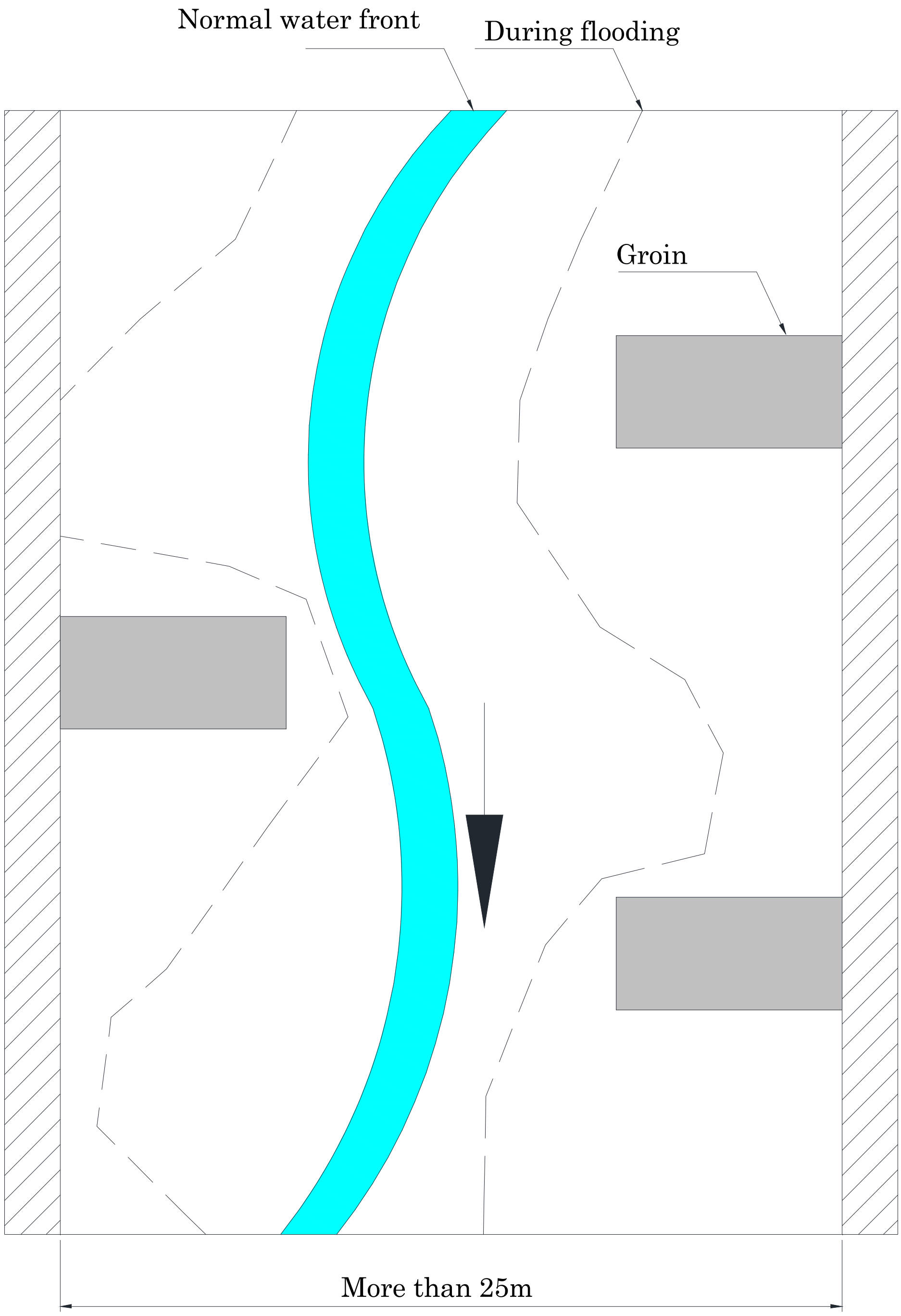


Image4.5.1　Graphic overview of building groins

4.6 Rehabilitation Method Total Check

This check list is to review the details under examination in respect of rehabilitation measure, and to reconsider the rehabilitation measure if necessary.

(1) Site investigation and grasp of the cause of damage

- ☑ Site investigation is performed.
- ☑ The cause of damage is grasped.
- ☑ Damaged part(s) and condition of surroundings are grasped.
- ☑ Table A is prepared.

(2) Selection of rehabilitation plan

- ☑ Response to the cause of damage
- ☑ Other points of attention in respect of design and workability

(3) Safety of the structure

- ☑ Design current velocity, deepest depth of scour, and boulders, etc. is grasped.
- ☑ As for slope protective works, a type of construction which is safe against design current velocity is selected.
- ☑ Table B is prepared.

(4) Environmental consideration

☑ Lumber from thinning or lumber generated in local site are used.

☑ Consideration is made in respect of rare species and remarkable animals and plants.

(5) Construction management

☑ Timing of construction

☑ Change in water colliding front

☑ Contrivance when constructing

(6) Cost reduction

☑ Cost reduction is taken into account.

(7) Maintenance

☑ The structure enables proper maintenance.

Chapter 5 Estimation of Cost for Flood Disaster Measures

This Chapter explains the labor cost and material unit price to calculate the estimation documents by each construction method and direct construction cost for flood measures.

As items to be estimated are based on Japanese system, if they are not aligned with the circumstances in Thailand, it is desirable to revise them from time to time.

Also, labor cost and material unit price differ according to regions even within Thailand; therefore, DRR staff is expected to keep doing the best to update the information and use the DRR estimation system.

5.1 Estimation of Post-Flood Rehabilitation Plan

The construction and rehabilitation methods of Table C and D are elaborated in these chapters.

Construction method where slope ratio is less than 1:1.5 (Table C)

Designation of method		Ref. page
C-1	Sodding	p.86
C-2	Synthetic geotextile sheet	p.87
C-3	Natural rock (not plastered with cement)	p.88
C-4	Natural rock (plastered with cement)	p.89
C-5	Stacking wire mesh boxes	p.90
C-6	Laying concrete boxes	p.91

Construction method where slope ratio is greater than 1:1.5 (Table D)

Designation of method		Ref. page
D-1	Natural rock (plastered with cement)	p.92
D-2	Multiple-layered wire mesh boxes	p.93
D-3	Stacking wire mesh boxes (not plastered with cement)	p.94
D-4	Stacking wire mesh boxes (plastered with cement)	p.95

(C-1) Sod

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.3	19,100	5,730	
2	General staff		Person	2.7	14,000	37,800	
3	Sod		m^2	100.0	410	41,000	
4	Miscellaneous expenses		%	3.0	84,530	2,536	Formula 1
	Total					87,066	
	Per 1 m^2					871	
					Estimated price	900	(yen/m^2)

Formula 1

Take account of miscellaneous expenses in total labor cost (Item 1, 2) and material cost (Item 3)

(1) + (2) + (3) ……………….(Formula 1)

・Miscellaneous expense ratio does not exceed a maximum of 3%

1) Civil engineer	5,730
2) General staff	37,800
3) Sod	41,000
Total	84,530

(C-2) Synthetic geotextile sheet

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.3	19,100	5,730	
2	General staff		Person	2.7	14,000	37,800	
3	Synthetic geotextile		m^2	100.0	2,000	200,000	
4	Miscellaneous expenses		%	3.0	243,530	7,306	Formula 1
	Total					250,836	
	Per 1 m^2					2,508	
					Estimated price	2,500	(yen/m^2)

Formula 1

Take account of miscellaneous expenses in total labor cost (Item 1, 2) and material cost (Item 3)

(1) + (2) + (3) ……………….(Formula 1)

・Miscellaneous expense ratio does not exceed a maximum of 3%

1) Civil engineer	5,730
2) General staff	37,800
3) Synthetic geotextile	200,000
Total	243,530

(C-3) Natural rock (not plastered with cement)

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.58	19,100	11,078	
2	Expert		Person	0.58	17,300	10,034	
3	General staff		Person	1.15	14,000	16,100	
4	Rock material		m^2	10.0	1,500	15,000	
5	Backfill material	Recycled crushed rock	m^3	2.4	1,200	2,880	Formula 1
6	Filler material	Pieces of rock and concrete	m^3	2.26	4,500	10,170	Formula 2
7	Soil retention membrane	Thickness 10mm	m^2	10.9	510	5,559	Formula 3
8	4-wheel crane driving	Lift 25t	วัน	0.3	38,400	11,520	
9	Backhoe driving	Load bearing 0.8m^3	hr	1.79	9,187	16,445	
10	Miscellaneous expenses		%	1.0	37,212	372	Formula 4
	Total					99,158	
	Per 1 m^2					9,916	
					Estimated price	9,900	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)……………….(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of filler material (m^3) = Design quantity x (1 + K)……………….(Formula 2)

・Standard loss rate K is set at 13%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.13) = 2.26(m^3)

Formula 3

Usage quantity of soil retaining material (m^2) = Design quantity x (1 + K)……………….(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retaining material per 10(m^2) = 10(m^2) x (1 + 0.09) = 10.9(m^2)

Formula 4

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

・Miscellaneous expense ratio does not exceed a maximum of 1%

1) Civil engineer		11,078
2) Expert		10,034
3) General staff		16,100
	Total	37,212

(C-4) Natural rock (plastered with cement)

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.83	19,100	15,853	
2	Expert		Person	1.30	17,300	22,490	
3	General staff		Person	1.94	14,000	27,160	
4	Rock material		m^2	10.0	1,500	15,000	
5	Backfill material	Recycled crushed rock	m^3	2.4	1,200	2,880	Formula 1
6	Filler material	Pieces of rock and concrete	m^3	1.120	11,800	13,216	Formula 2
7	Soil retainer membrane	Thickness 10mm	m^2	10.9	1,420	15,478	Formula 3
8	4-wheel crane driving	Lift 25t	Day	0.6	38,400	23,040	
9	Backhoe driving	Load bearing 0.8m^3	hr	2.38	9,187	21,865	
10	Miscellaneous expenses		%	8.0	65,503	5,240	Formula 4
	Total					162,222	
	Per 1 m^2					16,222	
					Estimated price	16,200	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)……………….(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of concrete filler (m^3) = [(D×10m2) - (VxN)]………………….(Formula 2)

・Suppose D is rock diameter which is equal to 0.5m.

Volume V=(pxD^3)/2, Area A'=(√3xD^2)/2, Basic quantity N=10/A'

Design quantity per 10(m^2) is equal to [0.5 x 10 - 0.06 x 46]/2 = 1.12(m^3)

Formula 3

Usage quantity of waterproof membrane (m^2) = Design quantity x (1 + K)………(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retention membrane per 10(m2) = 10(m2) x (1 + 0.09) = 10.9(m2)

Formula 4

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

・Miscellaneous expense ratio does not exceed a maximum of 1%

1) Civil engineer	15,853
2) Expert	22,490
3) General staff	27,160
Total	65,503

(C-5) Wire mesh box

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.8	19,100	15,280	
2	Expert		Person	1.2	17,300	20,760	
3	General staff		Person	9.9	14,000	138,600	
4	Wire mesh box	Thickness	m^2	100.0	5,690	569,000	
5	Pieces of rock and concrete		m^3	48.6	4,500	218,700	Formula 1
6	Soil retention membrane	Thickness	m^2	107.0	510	54,570	Formula 2
7	Backhoe driving	Load bearing 0.8m^3	hr	8.2	8,845	72,529	
8	Miscellaneous expenses		%	4.0	247,169	9,887	Formula 3
	Total					1,099,326	
	Per 1 m^2					10,993	
					Estimated price	11,000	(yen/m^2)

Formula 1

Usage quantity of mid-section rockfill material (m^3) = Design quantity x (1 + K)……………..(Formu

・Design quantity is set at 90% of wire mesh box volume

Design quantity per 100(m^2) is equal to 100($m^{2)}$)x 0.5(m) x 0.9 = 45(m^3)

・Standard loss rate K is set at 8%

Usage quantity of mid-section rockfill material per 100(m^2) = 45(m^3) x (1 + 0.08) = 48.6(m^3)

Formula 2

Usage quantity of soil retaining material (m^2) = Design quantity x (1 + K)…….(Formula 2)

・Standard loss rate K is set at 7%

Usage quantity of soil retaining material per 100(m^2) = 100(m^2) x (1 + 0.07) = 107(m^2)

Formula 3

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3) and equipment rental cost (Item 7)

(1) + (2) + (3)………………..(Formula 3)

・Miscellaneous expense ratio does not exceed a maximum of 4%

1) Civil engineer	15,280
2) Expert	20,760
3) General staff	138,600
7) Backhoe driving	72,529
Total	247,169

(C-6) Laying concrete block

Calculated unit price per 10 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.1	19,100	1,910	
2	Bricklayer		Person	0.2	19,200	3,840	
3	Special staff		Person	0.2	17,300	3,460	
4	General staff		Person	0.7	14,000	9,800	
5	Concrete block		m^2	10.0	10,000	100,000	
6	Soil retaining material installer	Thickness 10mm	m^2	11.2	510	5,712	Formula 1
7	4-wheel crane driving	Lift 25t	Day	0.2	38,400	7,680	
8	Miscellaneous expenses		%	4.0	26,690	1,068	Formula 2
	Total					133,470	
	Per 1 m^2					13,347	
					Estimated price	13,300	(yen/m^2)

Formula 1

Usage quantity of soil retaining material (m^2) = Design quantity x (1 + K)………(Formula 2)

・Standard loss rate K is set at 12%

Usage quantity of soil retaining material per 10(m^2) = 10(m^2) x (1 + 0.12) = 11.2(m^2)

Formula 2

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3) and equipment rental cost (Item 7)

(1) + (2) + (3) + (4) + (7)………………..(Formula 3)

・Miscellaneous expense ratio does not exceed a maximum of 4%

1)	Civil engineer	1,910
2)	Bricklayer	3,840
3)	Special staff	3,460
4)	General staff	9,800
7)	4-wheel crane driving	7,680
	Total	26,690

(D-1) Natural rock (plastered with cement)

Calculated unit price per 10 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.83	19,100	15,853	
2	Expert		Person	1.30	17,300	22,490	
3	General staff		Person	1.94	14,000	27,160	
4	Rock material		m^2	10.0	1,500	15,000	
5	Backfill material	Recycled crushed rock	m^3	2.4	1,200	2,880	Formula 1
6	Concrete	High pressure	m^3	1.120	11,800	13,216	Formula 2
7	Waterproof material	Thickness 10mm	m^2	10.9	1,420	15,478	Formula 3
8	4-wheel crane driving	Lift 25t	Day	0.6	38,400	23,040	
9	Backhoe driving	Load bearing 0.8m^3	hr	2.38	9,187	21,865	
10	Miscellaneous expenses		%	8.0	65,503	5,240	Formula 4
	Total					162,222	
	Per 1 m^2					16,222	
					Estimated price	16,200	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)……………..(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of concrete filler (m^3) = [(D×10m2) - (VxN)]………………….(Formula 2)

・Suppose D is rock diameter which is equal to 0.5m.

Volume V=(pxD^3)/2, Area A'=(√3xD^2)/2, Basic quantity N=10/A'

Design quantity per 10(m^2) is equal to [0.5 x 10 - 0.06 x 46]/2 = 1.12(m^3)

Formula 3

Usage quantity of waterproof membrane (m^2) = Design quantity x (1 + K)……….(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retention membrane per 10(m2$^)$ = 10(m2$^)$x (1 + 0.09) = 10.9(m2$^)$

Formula 1

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

・Miscellaneous expense ratio does exceed a maximum of 1%

1) Civil engineer		15,853
2) Expert		22,490
3) General staff		27,160
	Total	65,503

(D-2) Multi-layered wire mesh boxes

Calculated unit price per 350 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	General staff		Person	57.0	14,000	798,000	
2	Wire mesh box	Multi layers	m^2	350.0	5,690	1,991,500	
3	Pieces of rock and concrete		m^3	332.0	4,500	1,494,000	
4	Soil retention membrane	Thickness 10mm	m^2	600.0	510	306,000	
5	Backhoe driving	Load bearing 0.8m^3	hr	16.0	8,845	141,520	
	Total					4,731,020	
	Per 1 m^2					13,517	
					Estimated price	13,500	(yen/m^2)

(D-3) Concrete block (not plastered with cement)

Calculated unit price per 10 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		คน	0.58	19,100	11,078	
2	Expert		คน	0.58	17,300	10,034	
3	General staff		คน	1.15	14,000	16,100	
4	Concrete block		m^2	10.0	7,000	70,000	
5	Backfill material	Recycled crushed rock	m^3	2.40	1,200	2,880	Formula 1
6	Filler material	Pieces of rock and concrete	m^3	2.26	4,500	10,170	Formula 2
7	Soil retaining material	Thickness 10mm	m^2	10.9	510	5,559	Formula 3
8	4-wheel crane driving	Lift 25t	วัน	0.3	38,400	11,520	
9	Backhoe driving	Load bearing 0.8m^3	hr	1.79	9,187	16,445	
10	Miscellaneous expenses		%	1.0	37,212	372	Formula 4
	Total					154,158	
	Per 1m2					15,416	
	Per 1m2				Estimated price	15,400	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)…………(Formula 1)

- Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of filler material (m^3) = Design quantity x (1 + K)……………….(Formula 2)

- Standard loss rate K is set at 13%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.13) = 2.26(m^3)

Formula 3

Usage quantity of soil retaining material (m^2) = Design quantity x (1 + K)……….(Formula 3)

- Standard loss rate K is set at 9%

Usage quantity of soil retaining material per 10(m^2) = 10(m^2) x (1 + 0.09) = 10.9(m^2)

Formula 4

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

- Miscellaneous expense ratio does exceed a maximum of 1%

1) Civil engineer	11,078
2) Expert	10,034
3) General staff	16,100
Total	37,212

(D-4) Concrete block (not plastered with cement)

Calculated unit price per 10 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.83	19,100	15,853	
2	Expert		Person	1.30	17,300	22,490	
3	General staff		Person	1.94	14,000	27,160	
4	Concrete block		m^2	10.0	7,000	70,000	
5	Backfill material	Recycled crushed rock	m^3	2.4	1,200	2,880	Formula 1
6	Filler material	Pieces of rock and concrete	m^3	1.120	11,800	13,216	Formula 2
7	Soil retention membrane	Thickness 10mm	m^2	10.9	1,420	15,478	Formula 3
8	4-wheel crane driving	Lift 25t	Day	0.6	38,400	23,040	
9	Backhoe driving	Load bearing 0.8m^3	hr	2.38	9,187	21,865	
10	Miscellaneous expenses		%	8.0	65,503	5,240	Formula 4
	Total					217,222	
	Per 1m2					21,722	
					Estimated price	21,700	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)…………(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of concrete filler (m^3) = [(D×10m2) - (VxN)]………………….(Formula 2)

・Suppose D is rock diameter equal to 0.5m.

Volume V=(pxD^3)/2, Area A'=(√3xD^2)/2, Basic quantity N=10/A'

Design quantity per 10(m^2) is equal to [0.5 x 10 - 0.06 x 46]/2 = 1.12(m^3)

Formula 3

Usage quantity of waterproof membrane (m^2) = Design quantity x (1 + K)……….(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retention membrane per 10(m2) = 10(m2) x (1 + 0.09) = 10.9(m2)

Formula 4

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

・Miscellaneous expense ratio does exceed a maximum of 1%

1) Civil engineer		15,853
2) Expert		22,490
3) General staff		27,160
	Total	65,503

Chapter 6　Design Examples

This Chapter shows how to utilize this Manual, using examples of simple survey methods for the surrounding area of flood affected roads and bridges, preparation of design drawing of flood measures, and estimation of construction order, represented by pilot bridges.

Also, it is desirable to elaborate a set of actual instances performed based on these design examples for the purpose of flood measures and flood rehabilitation, to keep this Manual revised in the future.

Furthermore, methods of construction, details and points of attention for the measures are required to be revised, from time to time, according to the site conditions.

6.1　Examination Flow Represented by Pilot Bridges

This Manual explains about those bridges evaluated as emergency measures needed after conducting an emergency survey, as shown in the flowchart of "2.2 Inspection during flooding".

The procedure to examine rehabilitation measures after flood, represented by the pilot bridges, is described in the following pages.

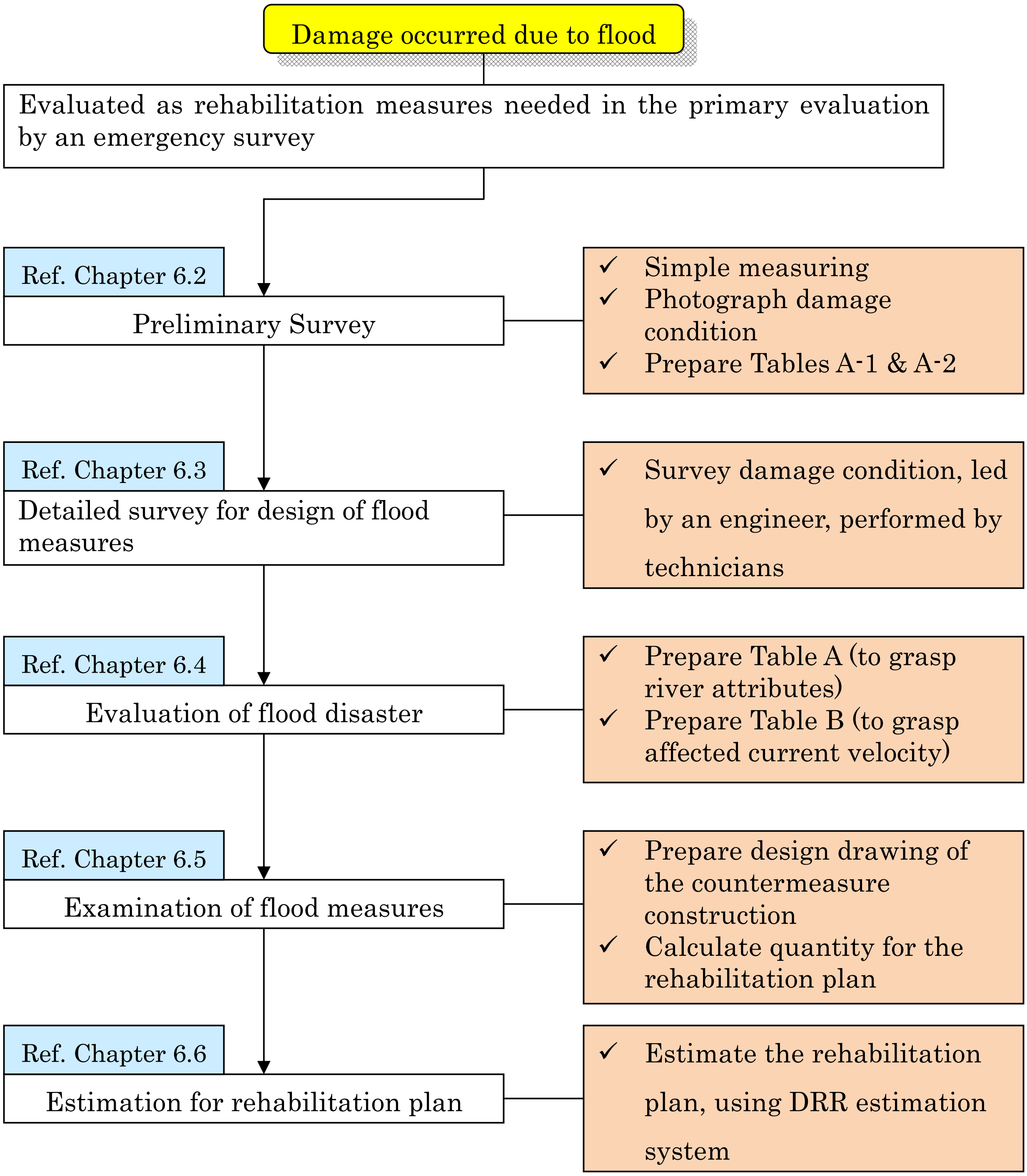
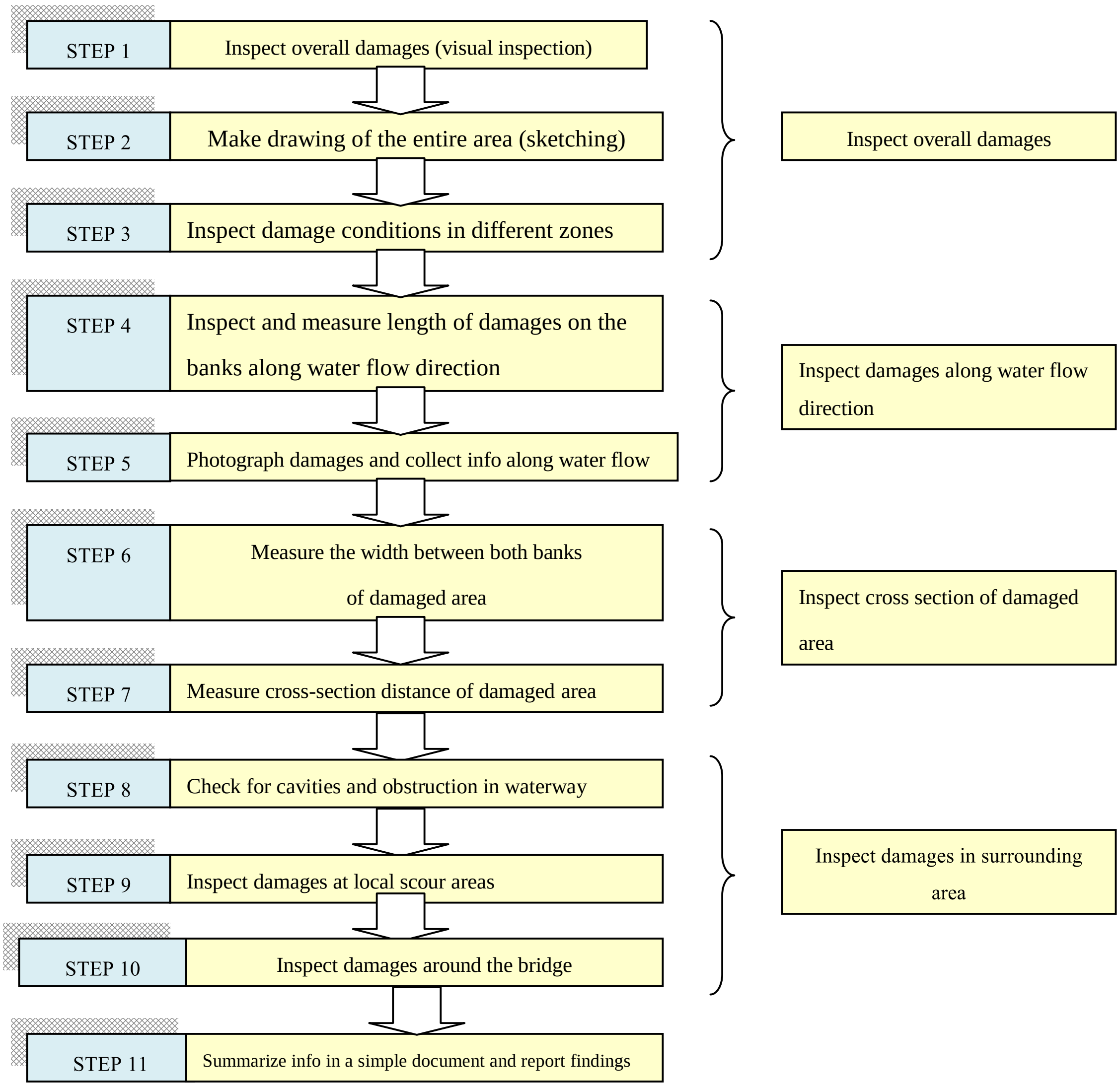


Image6.1.1 Examination flow of post-flood rehabilitation measures

6.2 Post-Flood Inspection

Overall operational steps are presented below. Details of each step are described in the next page.

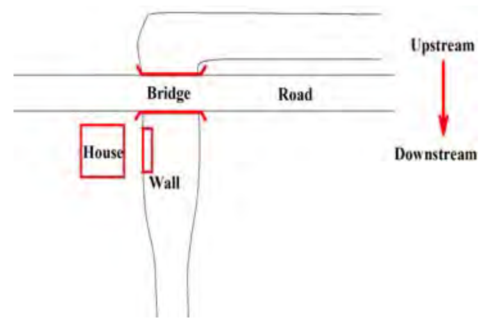


STEP 1 — Inspect overall damages (visual inspection)

- ✓ Bridge
- ✓ Form of river, water flow direction
- ✓ Check whether there are houses and public structures

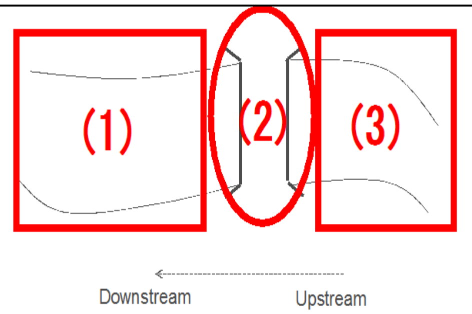
STEP 2 — Make drawing of the entire area (sketching)

- ✓ Sketch the entire area
- ✓ Specify water flow direction
- ✓ Indicate if any houses are in the vicinity
- ✓ Note other special structures



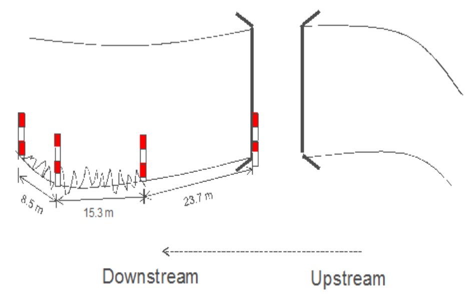
STEP 3 — Inspect damage conditions in different zones

- ✓ Inspect damage conditions in three zones
- ✓ (1) Downstream zone of the bridge
- ✓ (2) Under the bridge
- ✓ (3) Upstream zone of the bridge



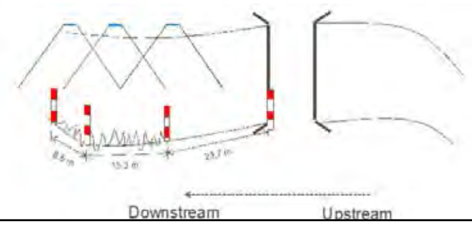
STEP 4 — Inspect and measure length of damages on the banks along water flow direction

- ✓ Plant poles to mark the beginning and end points
- ✓ Plant poles to mark spots where topography changes
- ✓ Measure distances by referring to the bridge's position



STEP 5 — Photograph damages and collect info along water flow direction

- ✓ Take pictures along the length of damaged area
- ✓ If damages extend over a long distance, take pictures and form overlapping photos



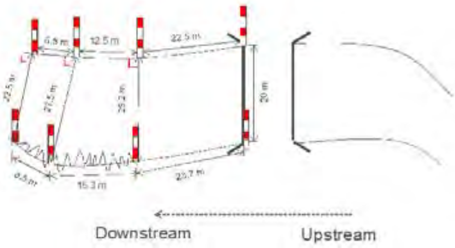
STEP 6 - Continue in the next page

STEP 5 From the previous page

STEP 6 Measure the width between both banks of damaged area

✓ Use a tape to measure the river's width at every spot where the width or water flow changes

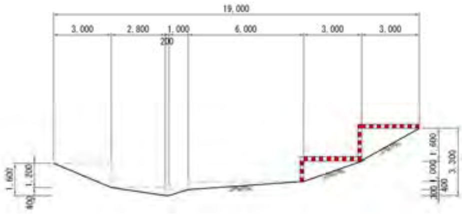
Make measurement across the channel; specify distances from the bridge



STEP 7 Measure cross-section distance of damaged area

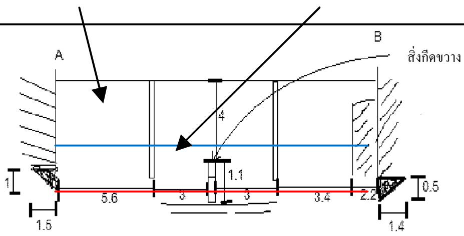
✓ Use poles or staffs to measure vertical and horizontal distances of the banks along cross section of waterway

Draw cross section view from upstream facing toward downstream direction



STEP 8 Check for cavities and obstruction in waterway

✓ Measure distances of obstruction in waterway and scours between the original ground level and abutments and girders

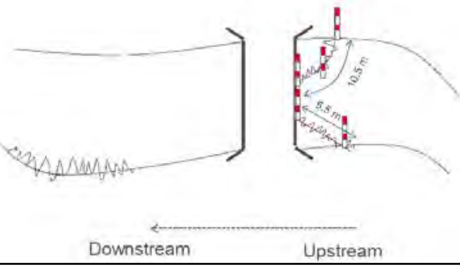


If a cavity is present, measure its width and depth

STEP 9 Inspect damages at local scour areas

✓ Measure length of damages at local scour areas

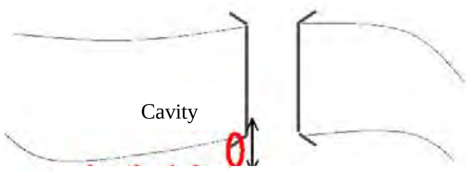
Record distances of scour positions



STEP 10 Inspect damages around the bridge

✓ Measure damages e.g. washed-away soil behind edge row abutments

Record cavity's distance from the bridge as well as its width and depth

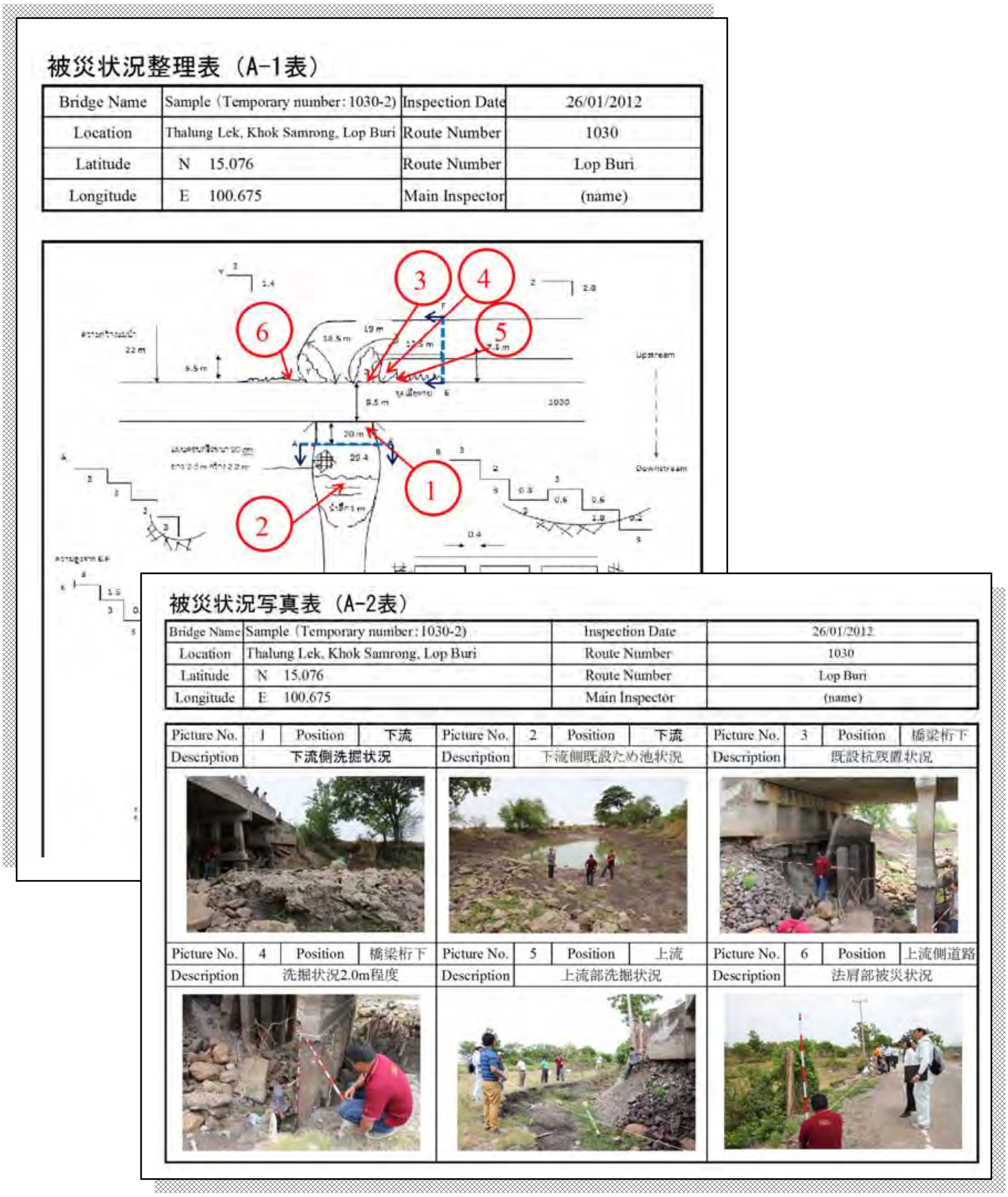


Depth=1.6 m Width = 5.0 m

STEP 11 Summarize info in a simple document and report findings

Based on the work flow, Table A-1 (Table showing damage conditions) and Table A-2 (Table showing damage pictures) are to be prepared.

- ✓ Table A-1 (Table showing damage conditions) ⇒Ref. Chapter 3.1.1
- ✓ Table A-2 (Table showing damage pictures) ⇒Ref. Chapter 3.1.2



被災状況整理表（A-1表）

Bridge Name	Sample (Temporary number: 1030-2)	Inspection Date	26/01/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N 15.076	Route Number	Lop Buri
Longitude	E 100.675	Main Inspector	(name)

被災状況写真表（A-2表）

Bridge Name	Sample (Temporary number: 1030-2)	Inspection Date	26/01/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N 15.076	Route Number	Lop Buri
Longitude	E 100.675	Main Inspector	(name)

Picture No.	1	Position	下流	Picture No.	2	Position	下流	Picture No.	3	Position	橋梁桁下
Description	下流側洗掘状況			Description	下流側既設ため池状況			Description	既設杭残置状況		
Picture No.	4	Position	橋梁桁下	Picture No.	5	Position	上流	Picture No.	6	Position	上流側道路
Description	洗掘状況2.0m程度			Description	上流部洗掘状況			Description	法肩部被災状況		

6.3 Detailed Survey of Flood Affected Site

Detailed survey is required for the purpose of preparing design drawing of detailed rehabilitation plan and order construction based on the estimation by calculating the quantity.

The following items are to be illustrated in a detailed survey drawing.

(Plan View)

- ✓ Show the direction of water flow.
- ✓ Clarify the position of reference point.
- ✓ Specify survey points of road management.
- ✓ Specify roads, bridge structures.
- ✓ Specify cross sectional survey point and survey direction.
- ✓ Specify survey centerline.

(Cross-Sectional View)

- ✓ Illustrate survey centerline and standard altitude.
- ✓ Illustrate roads and bridge structures.
- ✓ Illustrate remaining structures (existing abutments, existing piles of piers).
- ✓ Specify the water mark of floods.
- ✓ When there is scour, illustrate the topography before scouring with a broken line.

6.4 Evaluation of Flood Disaster

First of all, prepare Table B (Table for calculating design current velocity) using the simple survey result and detailed survey result.

Secondly, according to the planned slope, check the applied current velocity of each construction method in Tables C and D, and after performing total evaluation such as economy and workability, select the most appropriate post-flood rehabilitation method or countermeasure construction method.

Table6.4.1 List of construction and rehabilitation methods

Name of Bridge	1030-2	1030-3
Design current velocity(m/s)	2.3	2.6
Planned slope	1:1.0	1:1.0
Table for selecting the construction method	Table D	Table D
Name of construction method	D-2 Multilayered gabions	D-2 Multilayered gabions

The below is the Table B for the bridge 1030-2.

設計流速算定表（B表）（直線部）

【検討位置】

県　名	Lop Buri
路線名	1030
橋梁名	1030-2

【凡例】

(yellow)	数値・文章を入力
(white)	計算過程の自動出力
(pink)	検討結果の自動出力

		位置		No. 0	No. 1		備　考
河道諸元		低水路幅	[b (m)]	29	22		
		河床縦断勾配	[Ie]	1/400	1/400		
		左岸法勾配		2. 1	2. 6		
		右岸法勾配		3. 5	3. 4		
径　深		径深	[Rd (m)]	2. 0	0. 5		
設計水深		設計水位	[h (m)]	2. 8	0. 5		
		現況平均河床高	[Z (m)]	0. 0	0. 0		
		設計水深	[Hd (m)]	2. 8	0. 5		
粗度係数	各部粗度係数	河床部	$[n_1]$	0. 020	0. 020		
		左岸護岸部	$[n_2]$	0. 032	0. 032		
		右岸護岸部	$[n_3]$	0. 032	0. 032		
	潤辺	河床部	$[S_1]$	13. 3	19. 0		
		左岸護岸部	$[S_2]$	6. 5	1. 4		
		右岸護岸部	$[S_3]$	10. 2	1. 8		
		計	[S]	30. 0	22. 2		
	合成粗度係数	$\{n_1^{3/2} \times S_1\}$		0. 038	0. 054		
		$\{n_2^{3/2} \times S_2\}$		0. 037	0. 008		
		$\{n_3^{3/2} \times S_3\}$		0. 058	0. 010		
		計		0. 133	0. 072		
		合成粗度係数	N	0. 027	0. 022		
平均流速 [Vm]		$Vm=1/N \cdot Rd^{2/3} \cdot Ie^{1/2}$		2. 9	1. 4		
限界流速 [Vc]		$Vc=(g \cdot Rd)^{1/2}$		4. 4	2. 2		Vm>Vcの場合は条件を要確認
現況最大洗掘深（実測値）			[ΔZ]	0. 5	0. 0		
補正係数	固定床	α1=1					岩露出、深掘れ無い箇所
	移動床	{ΔZ/2Hd}		0. 09	0. 00		
		α1=1+{ΔZ/2Hd}		1. 09	1. 00		上限値は2とする
	根固工	bw/H1＞1　→　α2=0. 9 bw/H1≦1　→　α2=1. 0		1. 00	1. 00		根固工がある場合の補正係数
	α	採用補正係数α＝α1×α2		1. 09	1. 00		
代表流速 [Vo]		Vo ＝ α ・ Vm		3. 2	1. 4		
設計流速 $[V_D]$		V_D = meanVo		2. 3 (m/s)			

The below is the Table B for the bridge 1030-3.

設計流速算定表（B表）（直線部）

【検討位置】

県　名	Lop Buri
路線名	1030
橋梁名	1030-3

【凡例】

(黄色)	数値・文章を入力
(白)	計算過程の自動出力
(桃色)	検討結果の自動出力

河道諸元		位置		No. 1	No. 2	No. 3	備　考
		低水路幅	[b(m)]	36	15	17	
		河床縦断勾配	[Ie]	1/400	1/400	1/400	
		左岸法勾配		3.0	2.5	2.5	
		右岸法勾配		4.6	2.3	4.3	
径　深		径深	[Rd(m)]	2.2	1.1	1.1	
設計水深		設計水位	[h(m)]	3.8	1.6	1.7	
		現況平均河床高	[Z(m)]	0.0	0.0	0.0	
		設計水深	[Hd(m)]	3.8	1.6	1.7	
粗度係数	各部粗度係数	河床部	[n_1]	0.020	0.020	0.020	
		左岸護岸部	[n_2]	0.032	0.032	0.032	
		右岸護岸部	[n_3]	0.032	0.032	0.032	
	潤辺	河床部	[S_1]	7.1	7.3	5.4	
		左岸護岸部	[S_2]	12.0	4.3	4.6	
		右岸護岸部	[S_3]	17.9	4.0	7.5	
		計	[S]	37.0	15.6	17.5	
	合成粗度係数	$\{n_1^{3/2} \times S_1\}$		0.020	0.021	0.015	
		$\{n_2^{3/2} \times S_2\}$		0.069	0.025	0.026	
		$\{n_3^{3/2} \times S_3\}$		0.102	0.023	0.043	
		計		0.191	0.069	0.084	
		合成粗度係数	N	0.030	0.027	0.028	
平均流速 [Vm]		$Vm=1/N \cdot Rd^{2/3} \cdot Ie^{1/2}$		2.8	2.0	1.9	
限界流速 [Vc]		$Vc=(g \cdot Rd)^{1/2}$		4.6	3.3	3.3	Vm>Vcの場合は条件を要確認
現況最大洗掘深（実測値）			[△Z]	0.5	1.0	0.5	
補正係数	固定床	$\alpha 1=1$					岩露出、深掘れ無い箇所
	移動床	{△Z/2Hd}		0.07	0.31	0.15	
		$\alpha 1=1+\{\Delta Z/2Hd\}$		1.07	1.31	1.15	上限値は2とする
	根固工	bw/H1＞1　→　$\alpha 2=0.9$ bw/H1≦1　→　$\alpha 2=1.0$		1.00	1.00	1.00	根固工がある場合の補正係数
	α	採用補正係数 $\alpha=\alpha 1 \times \alpha 2$		1.07	1.31	1.15	
代表流速 [Vo]		$Vo = \alpha \cdot Vm$		3.0	2.6	2.2	
設計流速 [V_D]		V_D = meanVo		2.6(m/s)			

6.5 Examination of the Methods of Flood Measures

Elaborate a design drawing of the scope of the construction and rehabilitation plan and depth of establishment, referring to the detailed survey drawing, and calculate the quantity for ordering the construction.

After calculating the quantity for construction, summarize it in Table A (Table showing river attributes where rehabilitation is undertaken) to estimate the construction cost.

Also, it is effective in directing the construction to describe the construction procedure in a flowchart concretely and prepare construction procedure drawing using the detailed survey drawing of the area where the construction is undertaken.

Table6.5.1 Sample of Table A（Bridge 1030-2）

ตารางแสดงลักษณะเฉพาะของลำน้ำในบริเวณที่ทำการฟื้นฟูความเสียหาย (ตาราง A)

ชื่อสะพาน	Sample (Temporary number : 1030-2)	
ที่ตั้ง	Thalung Lek, Khok Samrong, Lop Buri	
ละติจูด	N	15.076
ลองจิจูด	E	100.675

วันที่ทำการสำรวจ	26/01/2012
หมายเลขเส้นทาง	1030
จังหวัด	Lop Buri
ผู้สำรวจหลัก	(name)

สภาพปัจจุบันก่อนฟื้นฟู

[illegible]	[illegible]	50(m)				
	[illegible]	☑ [illegible]	☐ [illegible]	☐ [illegible]	☐ [illegible]	
	[illegible]	☐ [illegible]	☐ [illegible]	☑ [illegible]		
	[illegible]	☑ [illegible]	☐ [illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	ไม่มี				
	[illegible]	ไม่มี				
	[illegible]	ไม่มี				
[illegible]	[illegible]	☑ [illegible]	☐ [illegible]			
	[illegible]	☐ [illegible]	☑ [illegible]	☐ [illegible]		
[illegible]	[illegible]	☑ [illegible]	☐ [illegible]	☐ [illegible]	☐ [illegible]	☐ [illegible]
	[illegible]	0.5(mm)				

คำอธิบาย

เติมภายในหัวข้อด้วยประเภทการใส่สีด้านล่างนี้

(yellow)	ป้อนตัวเลขและข้อความลงในหัวข้อด้วยมือ
(green)	เลือกรายการที่เข้าข่าย
(pink)	คำนวณอัตโนมัติด้วยโปรแกรม Excel

การพิจารณาวิธีก่อสร้างฟื้นฟู

(1) [illegible]	[illegible]			
(2) [illegible]	☐ [illegible]	☐ [illegible]	☑ [illegible]	☑ [illegible]
(3) [illegible]	[illegible]		1:1.0	
	[illegible]		2.3(m/s)	
(4) [illegible]	ทุ่งนา			
(5) [illegible]				
(6) [illegible]				

การกำหนดวิธีก่อสร้างฟื้นฟู

[illegible]	☐	ลาดชันน้อยกว่า 1:1.5 ⇒ กำหนดจาก (ตาราง C)
	☑	ลาดชันมากกว่า 1:1.5 ⇒ กำหนดจาก (ตาราง D)
[illegible]	D:	กล่องลวดตาข่ายวางซ้อนหลายชั้น
[illegible]	340 (m2)	
[illegible]	13500 (เยน /m^2)	
[illegible]	6,750,000 (เยน)	

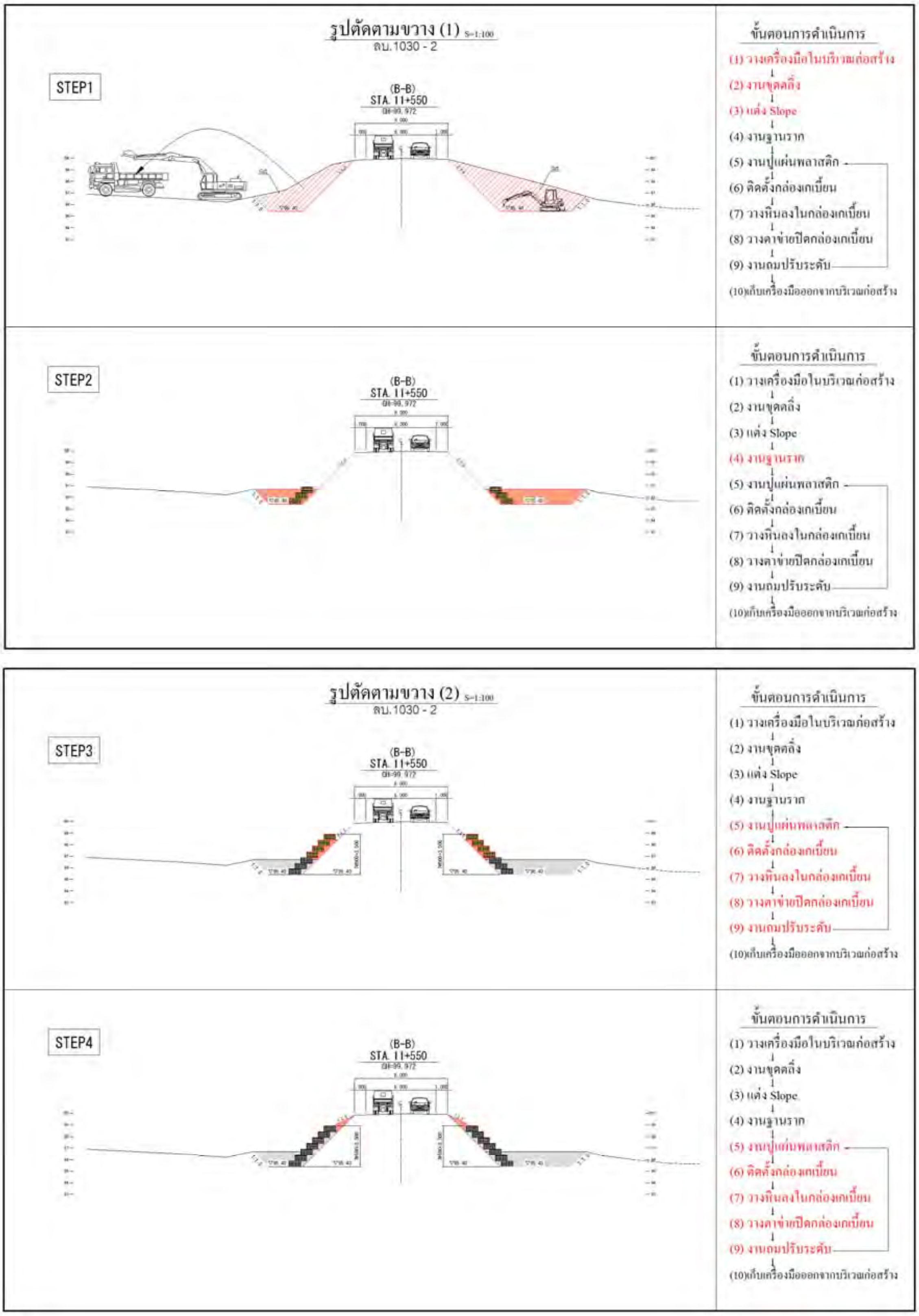


Image6.5.1　Construction Procedure Drawing (reference)

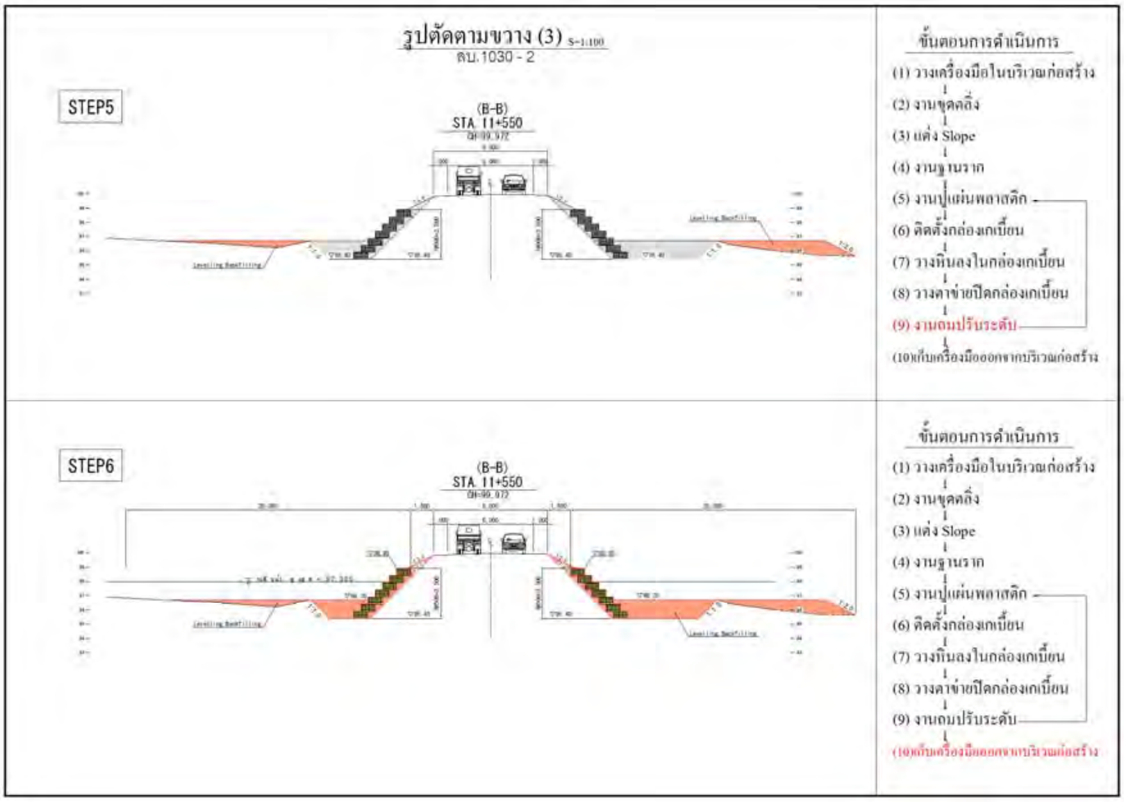
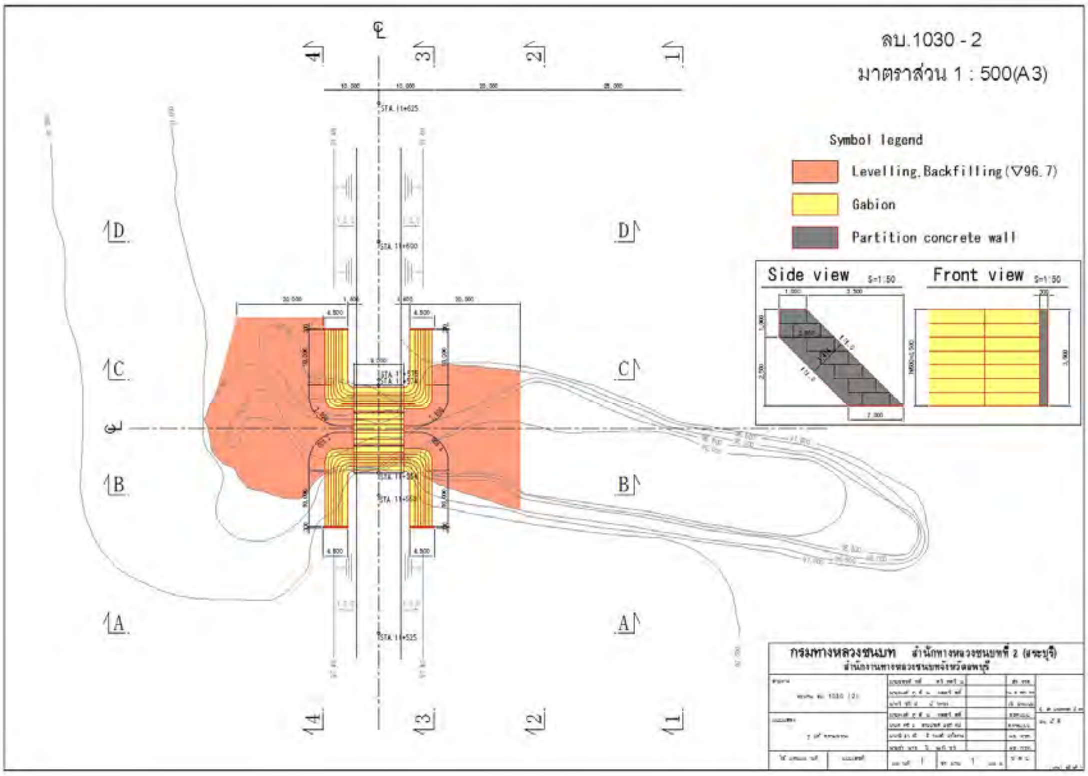


Image6.5.2 Construction Procedure Drawing (reference)



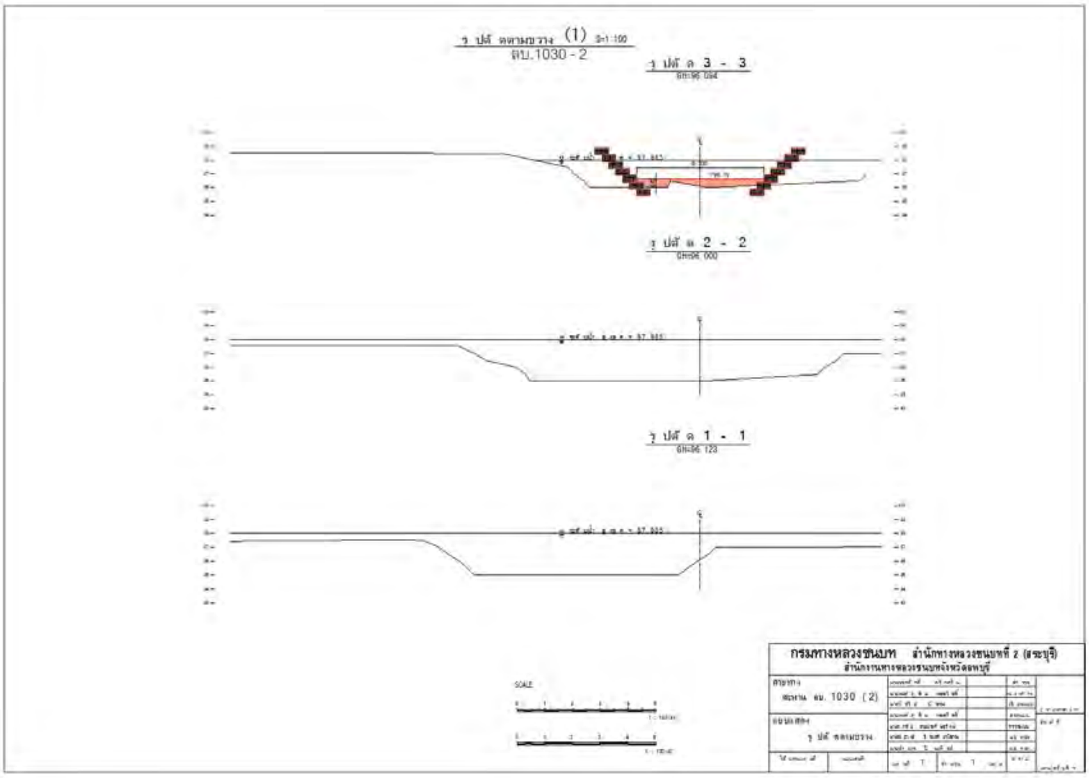
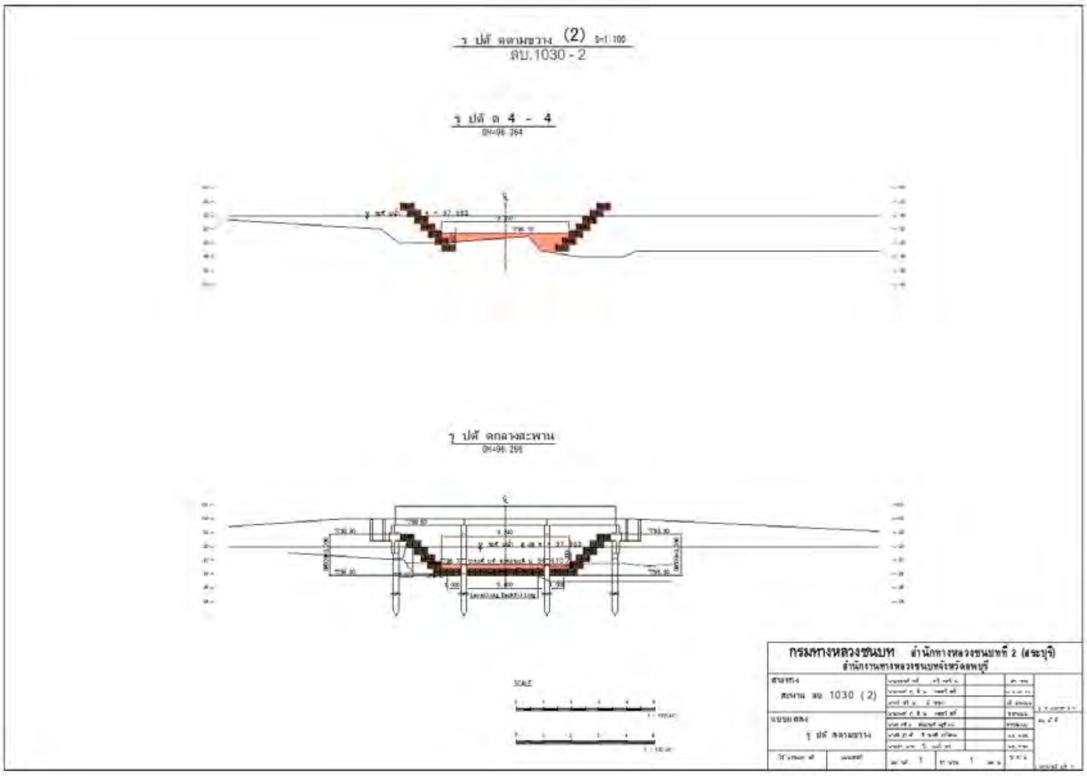


Image6.5.3　Design drawing of rehabilitation plan (Bridge 1030-2)



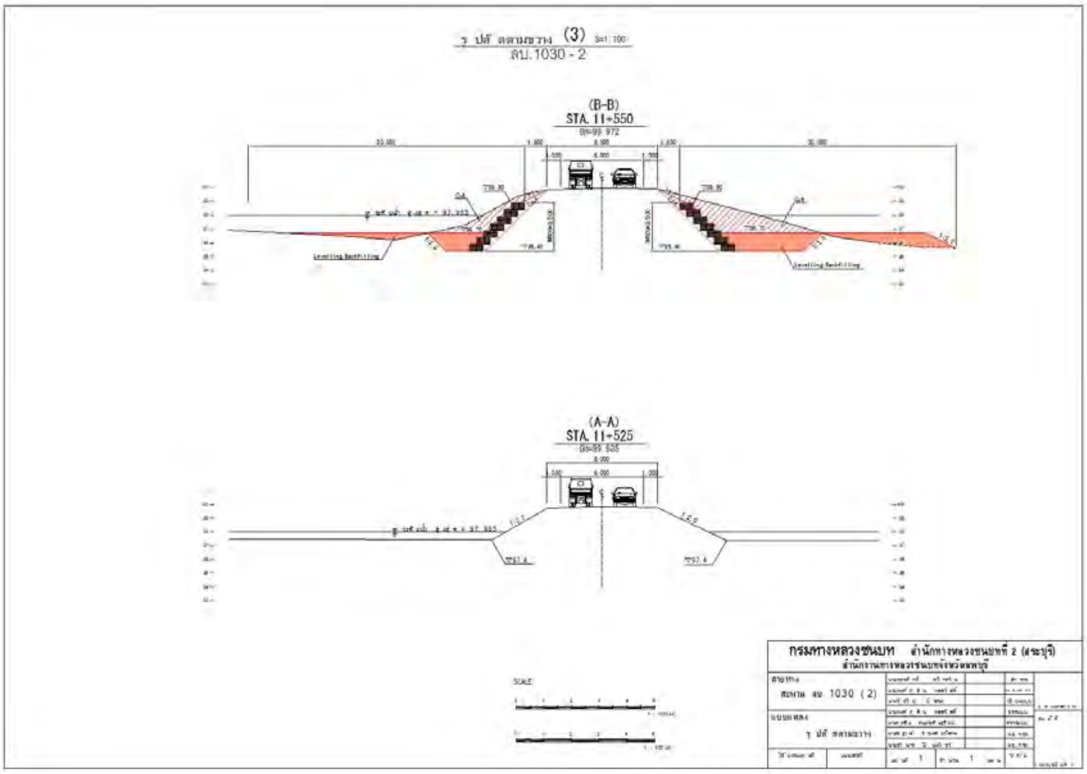


Image6.5.4　Design drawing of rehabilitation plan (Bridge1030-2)

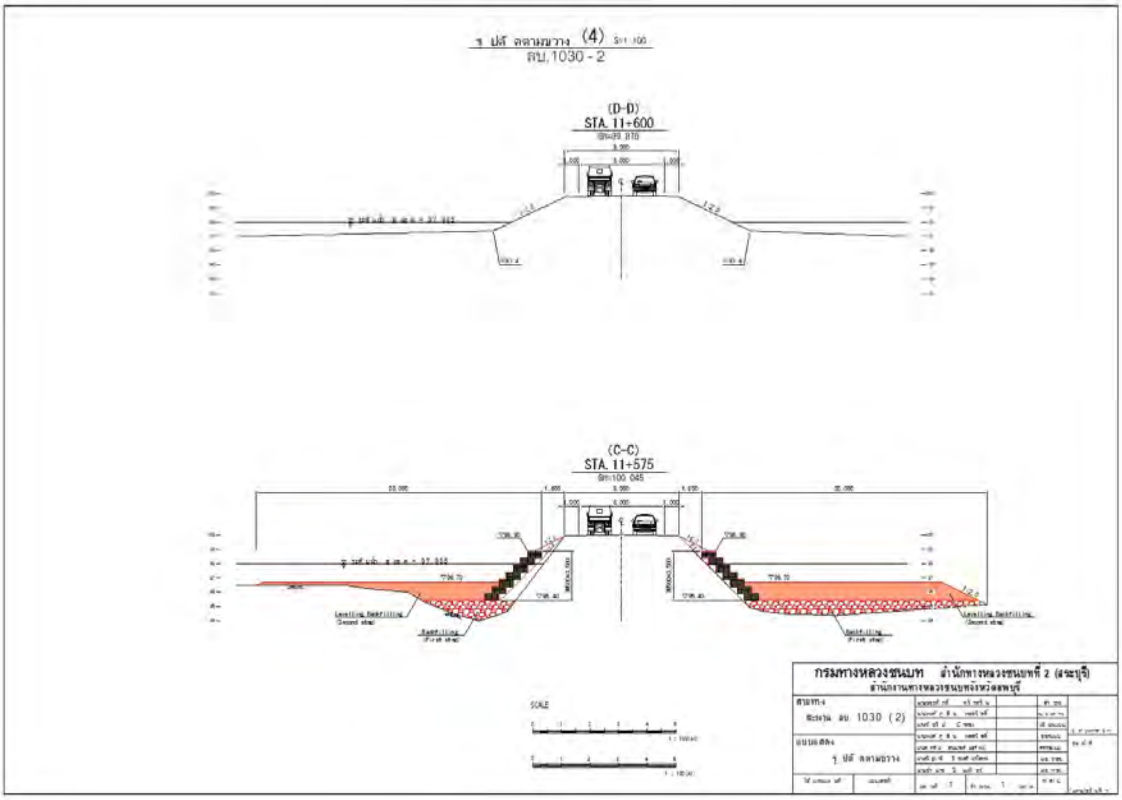
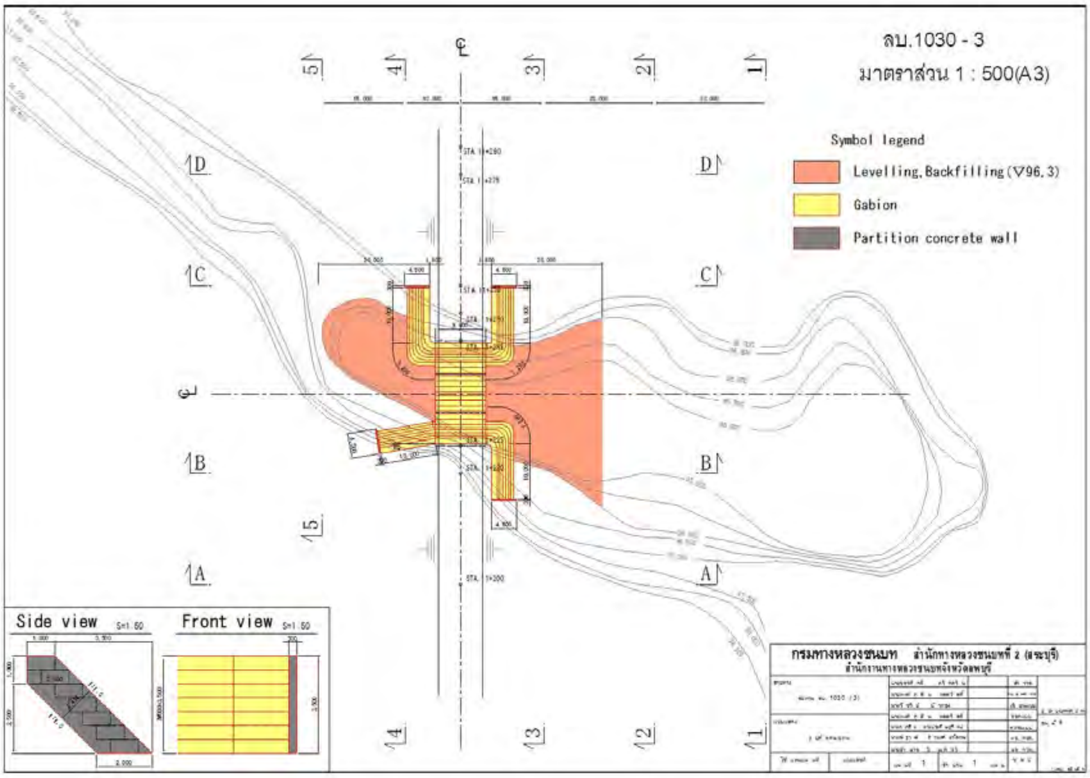


Image6.5.5 Design drawing of rehabilitation plan (Bridge1030-2)



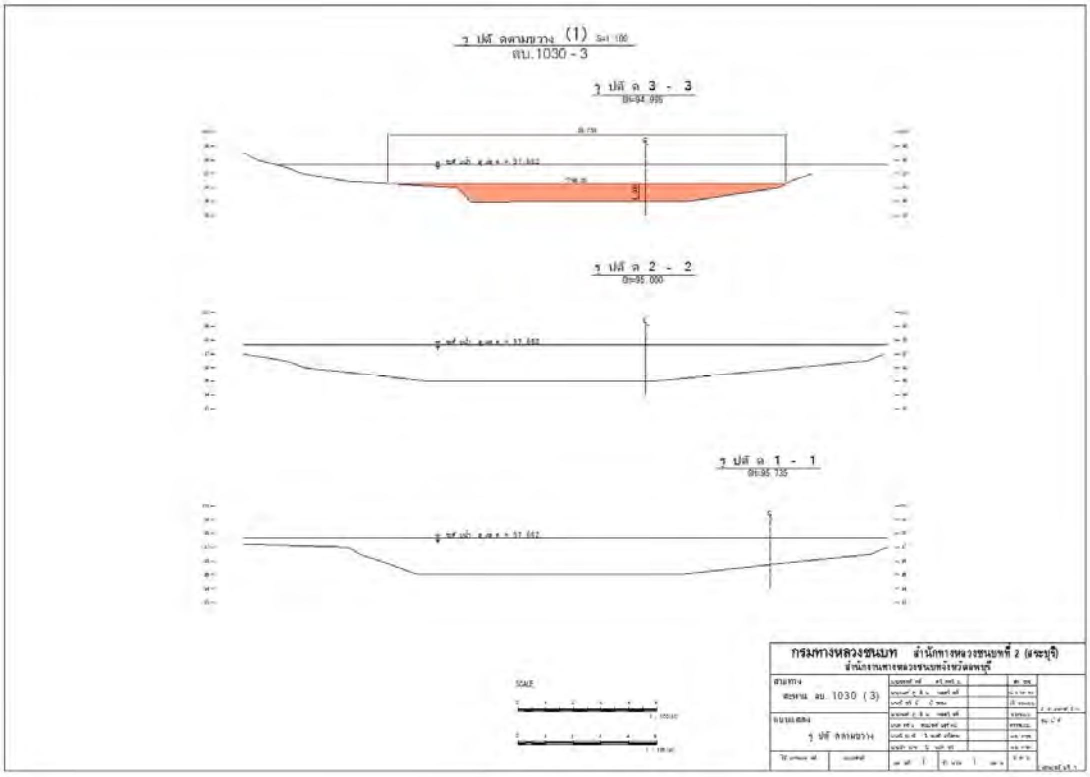
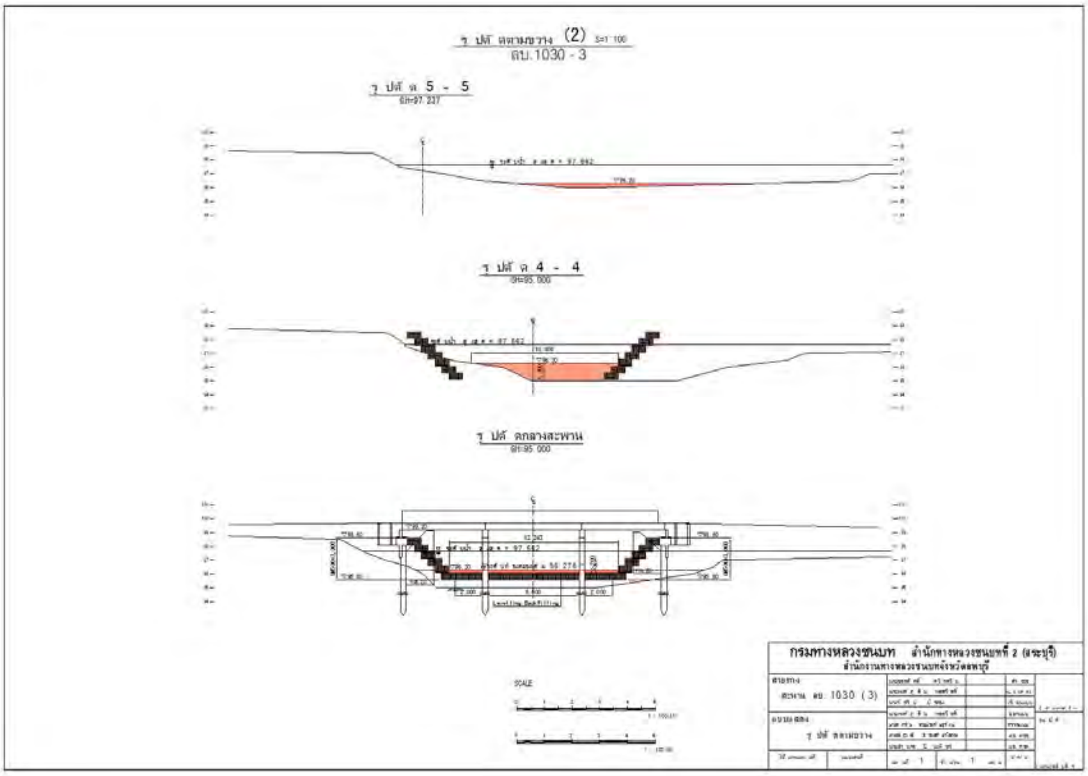


Image6.5.6　Design drawing of rehabilitation plan (Bridge1030-3)



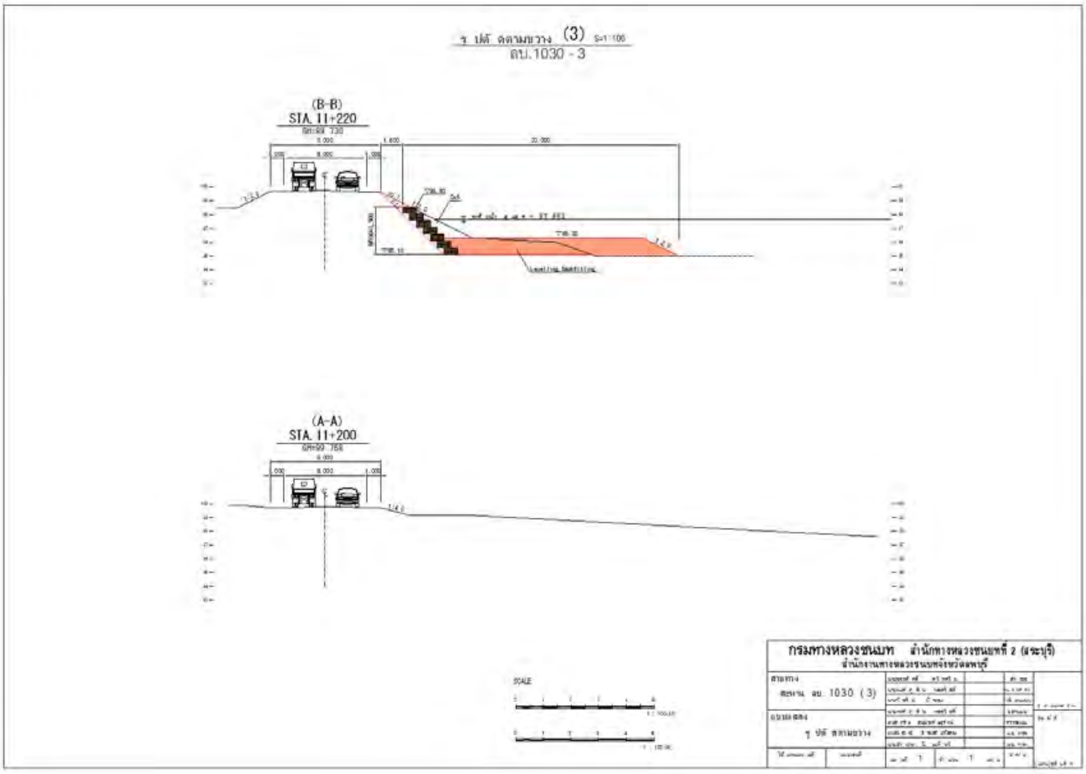


Image6.5.7　Design drawing of rehabilitation plan（Bridge 1030-3）

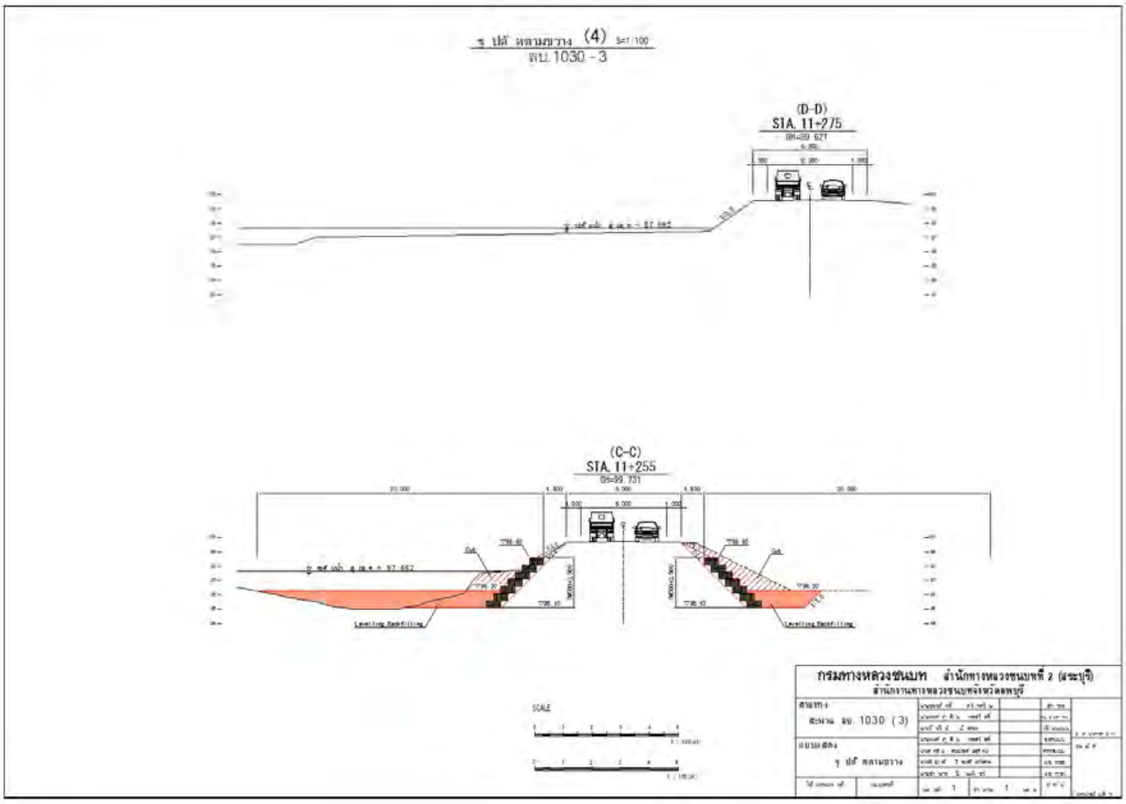


Image6.5.8　Design drawing of rehabilitation plan（Bridge1030-3）

6.6 Estimate for Ordering Construction

Following pages are the estimation based on the Japanese estimation standard, using the quantity calculated for the bridges 1030-2 and 1030-3, which are subject to pilot construction.

Also, an extract of a B.O.Q document prepared by using the DRR estimation system is shown for reference.

Table6.6.1 List of rehabilitation plans

Name of bridge	1030-2	1030-3
Direct construction cost (excl. overhead cost)	5 million yen	5 million yen

[1030-2]B.O.Q

Type of works	Quantity		Unit price (yen)	Cost (yen)	Remarks
Gabion	334.6	m^2	13,500	4,517,100	Material and construction cost
Rubble	317.4	m^3			
Mat	573.6	m^2			
Concrete	7.8	m^3	35,000	273,000	
Backfilling (*1)	263.2	m^3	300	78,960	Construiction cost(*2)
Total				4,869,060	
Approximate				5,000,000	

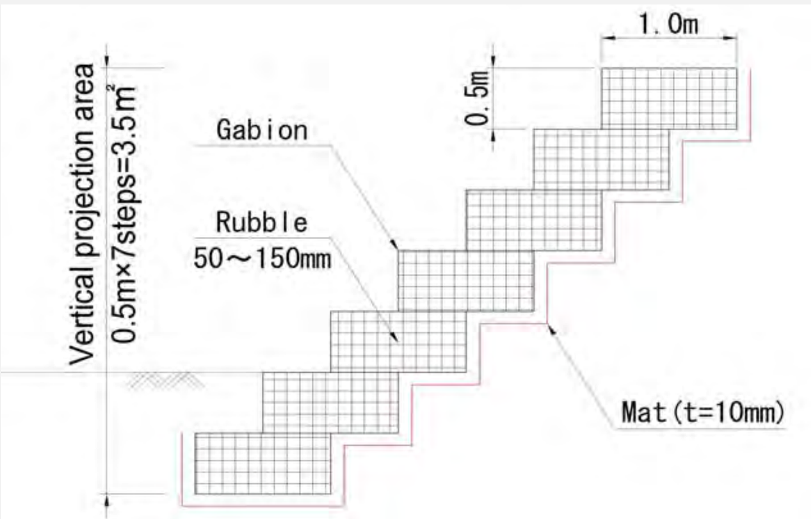
*1) If the backfiling material is available near the construction site,
it is not necessary to purchase.
If not, the backfilling material shall be purchased.
*2) Including only labor and machinery costs.

(Reference : Japanese standards)

(per vertical projection area of 350m^2)

Items	Description	Unit	Quantity	Remarks
Gabion	Multilayer type	m^2	350	(*3)
Rubble	50~150mm	m^3	332	
Worker		person	57	
Backhoe	Oil-pressure crawler, Bucket size:0.6m^3	hour	16	
Mat	t=10mm	m^2	600	

*3) The quantity of Gabion is the vertical projection area.



[1] Gabion

(1) h=3.5m

Height(m)		Length(m)		Vertical projection area (m2)
3.5	×	17.6	=	61.6 (m^2)
		nos.		
61.6(m2)	×	4	=	246.4 (m^2) ･･･①

(2) h=3.0m

Height(m)		Length(m)		Vertical projection area (m2)
3.0	×	9.0	=	27.0 (m^2)
		nos.		
27.0(m2)	×	2	=	54.0 (m^2) ･･･②

(3) h=0.5m

Height(m)		Length(m)		Vertical projection area (m2)
0.5	×	7.6	=	3.8 (m^2)
		nos.		
3.8(m2)	×	9	=	34.2 (m^2) ･･･③

Total vertical projection area

	①	+	②	+	③
=	246.4	+	54.0	+	34.2
=	334.6(m2)				

[2] Rubble

350.0(m2)	:	332.0(m3)	=	334.6(m2)	:	X
		X	=	317.4 (m3)		

[3] Mat (prevention of soil suck-out)

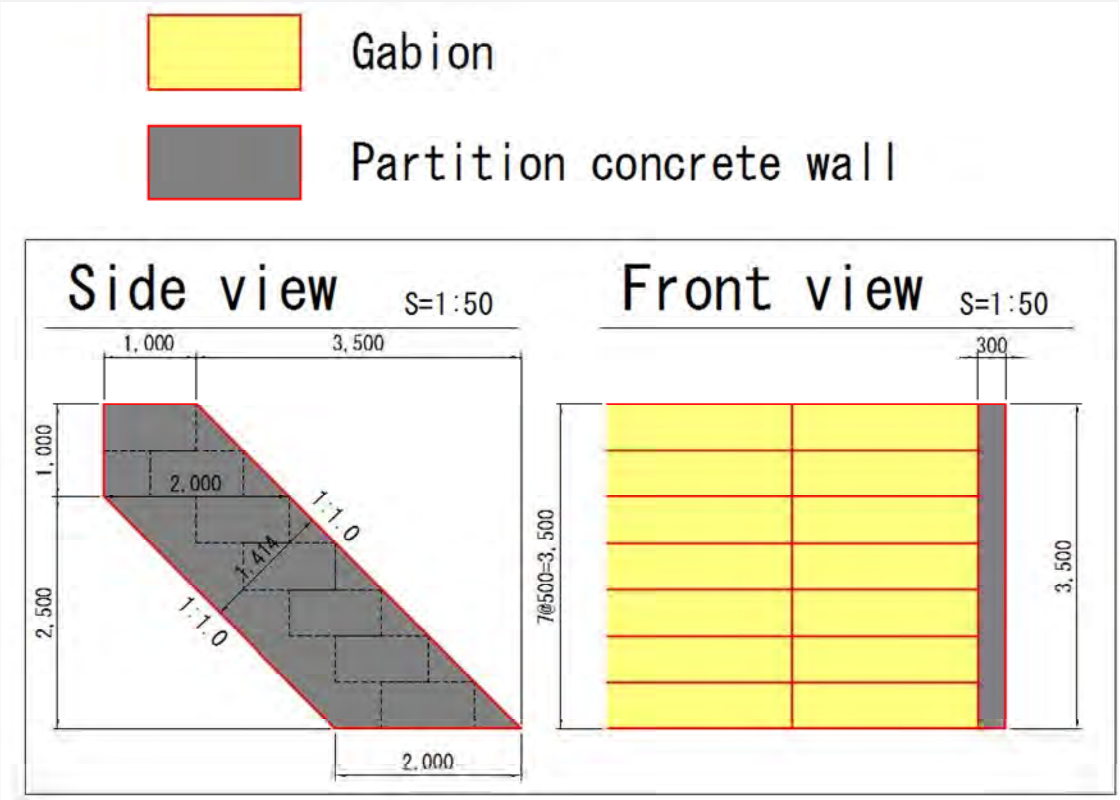
350.0(m2)	:	600.0(m2)	=	334.6(m2)	:	Y
		Y	=	573.6 (m2)		

[4] Concrete

S	=	2.0	×	2.5			
	+	1/2	×(	1.0	+	2.0	)×1.0
	=	6.5(m2)					

		nos.			
6.5(m2)	×	4	=	26.0	(m^2)

V	=	26.0(m2)	×	0.3(m)	=	7.8(m3)



[5] Backfilling

(1) Upstream (Section: 4-4)

		Width		Height			
S	=	9.2(m)	×	0.6(m)	=	5.5(m2)	
V	=	5.5(m2)	×	20.0(m)	=	110.0(m3)	･･･①

(2) Midstream (Section: center of bridge)

		Width		Height			
S	=	9.2(m)	×	0.3(m)	=	2.8(m2)	
V	=	2.8(m2)	×	9.0(m)	=	25.2(m3)	･･･②

(3) Downstream (Section: 3-3)

		Width		Height			
S	=	9.2(m)	×	0.7(m)	=	6.4(m2)	
V	=	6.4(m2)	×	20.0(m)	=	128.0(m3)	･･･③

Total volume

	①	＋	②	＋	③
＝	110.0	＋	25.2	＋	128.0
＝	263.2(m3)				

[1030-3]B.O.Q

Type of works	Quantity		Unit price (yen)	Cost (yen)	Remarks
Gabion	317.3	m^2	13,500	4,283,550	Material and construction cost
Rubble	301.0	m^3			
Mat	543.9	m^2			
Concrete	7.8	m^3	35,000	273,000	
Backfilling (*1)	1043.6	m^3	300	313,080	Construiction cost(*2)
Total				4,869,630	
Approximate				5,000,000	

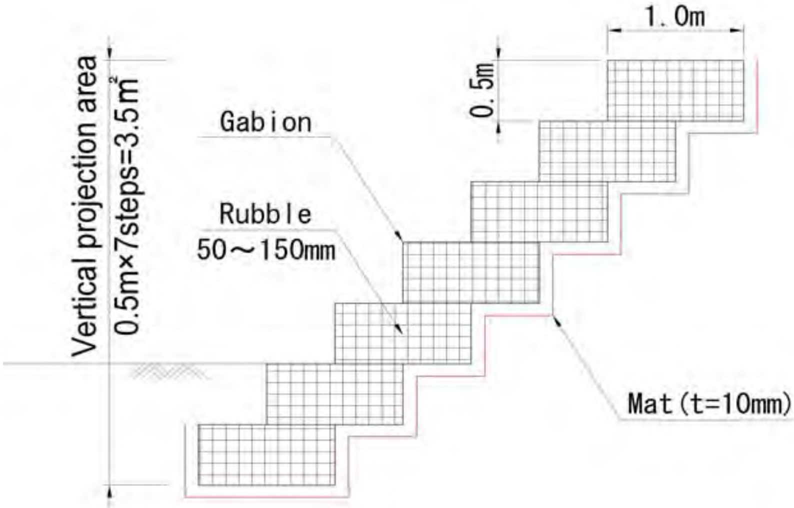
*1) If the backfiling material is available near the construction site,
it is not necessary to purchase.
If not, the backfilling material shall be purchased.
*2) Including only labor and machinery costs.

(Reference： Japanese standards)

(per vertical projection area of 350m^2)

Items	Description	Unit	Quantity	Remarks
Gabion	Multilayer type	m^2	350	(*3)
Rubble	50~150mm	m^3	332	
Worker		person	57	
Backhoe	Oil-pressure crawler, Bucket size:0.6m^3	hour	16	
Mat	t=10mm	m^2	600	

*3) The quantity of Gabion is the vertical projection area.



[1] Gabion

(1) h=3.5m

Height(m)		Length(m)		Vertical projection area (m2)	
3.5	×	17.2	＝	60.2 (m^2)	
3.5	×	10.0	＝	35.0 (m^2)	
		nos.			
60.2(m2)	×	3	＝	180.6 (m^2)	
35.0(m2)	×	1	＝	35.0 (m^2)	
180.6(m2)	+	35.0(m2)	＝	215.6 (m^2)	・・・①

(2) h=3.0m

Height(m)		Length(m)		Vertical projection area (m2)	
3.0	×	9.0	＝	27.0 (m^2)	
		nos.			
27.0(m2)	×	2	＝	54.0 (m^2)	・・・②

(3) h=0.5m

Height(m)		Length(m)		Vertical projection area (m2)	
0.5	×	10.6	＝	5.3 (m^2)	
		nos.			
5.3(m2)	×	9	＝	47.7 (m^2)	・・・③

Total vertical projection area

	①	＋	②	＋	③
＝	215.6	＋	54.0	＋	47.7
＝	317.3(m2)				

[2] Rubble

350.0(m2)	:	332.0(m3)	＝	317.3(m2)	:	X
		X	＝	301.0 (m3)		

[3] Mat (prevention of soil suck-out)

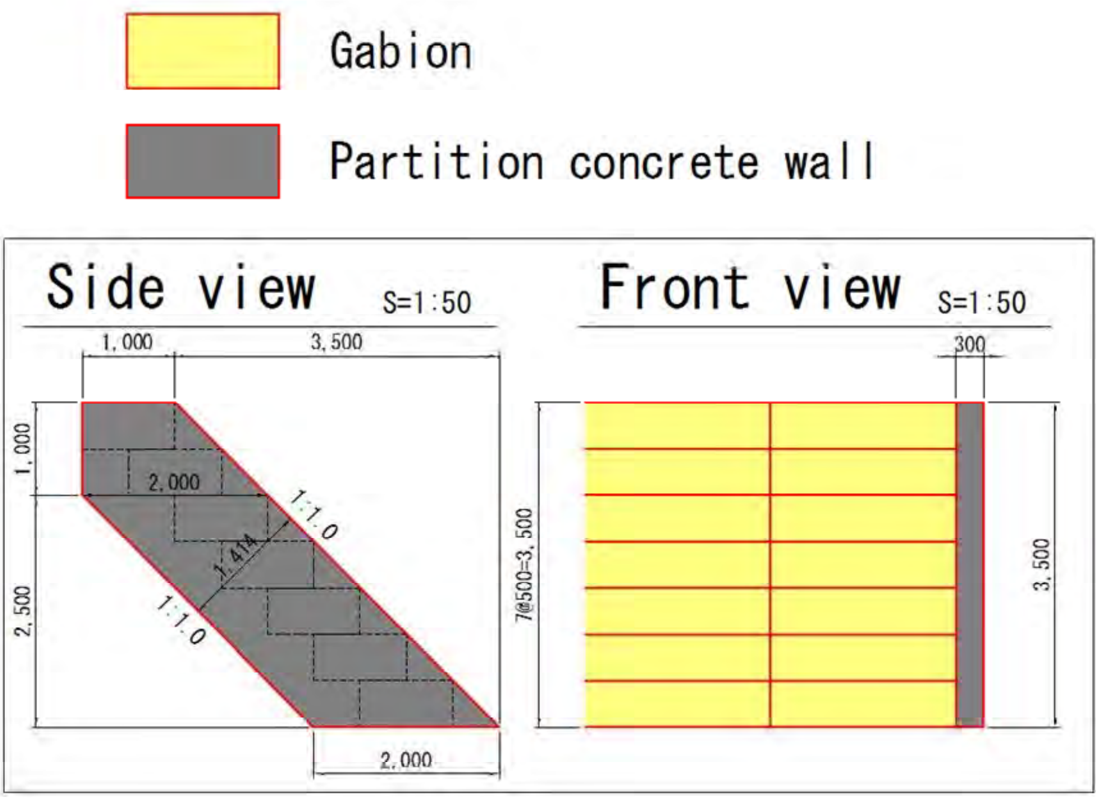
350.0(m2)	:	600.0(m2)	＝	317.3(m2)	:	Y
		Y	＝	543.9 (m2)		

[4] Concrete

S	=	2.0	×	2.5			
	+	1/2	×(	1.0	+	2.0	)×1.0
	=	6.5(m2)					

		Locations			
6.5(m2)	×	4	=	26.0	(m^2)

V	=	26.0(m2)	×	0.3(m)	=	7.8(m3)



[5] Backfilling

(1) Upstream (Section: 4-4)

		Width		Height			
S	=	10.6(m)	×	1.3(m)	=	13.8(m2)	
V	=	13.8(m2)	×	20.0(m)	=	276.0(m3)	･･･①

(2) Midstream (Section: center of bridge)

		Width		Height			
S	=	12.2(m)	×	0.2(m)	=	2.4(m2)	
V	=	2.4(m2)	×	9.0(m)	=	21.6(m3)	･･･②

(3) Downstream (Section: 3-3)

		Width		Height			
S	=	28.7(m)	×	1.3(m)	=	37.3(m2)	
V	=	37.3(m2)	×	20.0(m)	=	746.0(m3)	･･･③

Total volume

	①	＋	②	＋	③
＝	276.0	＋	21.6	＋	746.0
＝	1043.6(m3)				

An extract from a B.O.Q. document by using the DRR estimation system is shown as below.

แบบฟอร์มสรุปผลการประมาณราคาค่าก่อสร้าง

โครงการซ่อมบำรุงสะพาน ภายใต้ความร่วมมือระหว่างกรมทางหลวงชนบทและองค์การความร่วมมือระหว่างประเทศของญี่ปุ่น JICA

ส่วนราชการ กลุ่ม/ส่วน. วิชาการและถ่ายทอดเทคโนโลยี สำนักทางหลวงชนบทที่ 2 (สระบุรี)
กรมทางหลวงชนบท กระทรวงคมนาคม

ประเภทงาน งานซ่อมบำรุงสะพานในเขตชุมชน ในภูมิภาค

สถานที่ก่อสร้าง ลบ.1030-3 บ้านถลุงเหล็ก ตำบลถลุงเหล็ก อำเภอโคกสำโรง จังหวัดลพบุรี

ขนาดโครงการ "งานสะพานผิวจราจรกว้าง 6.00 เมตร ทางเท้ากว้างข้างละ 1.00 เมตร (Skew 0)

สรุปราคาตามแบบฟอร์ม ปร. 4/1 ส. จำนวน 4 แผ่น ปร. 4/3 ส. จำนวน 1 แผ่น
ปร. 4/2 ส. จำนวน 2 แผ่น

ออกแบบ/รายการ สำนักงานทางหลวงชนบทจังหวัดลพบุรี กรมทางหลวงชนบท ; กุมภาพันธ์ 2555 ประมาณการวันที่ 7 กุมภาพันธ์ 2556

ลำดับที่	รายการ	รวมค่างานต้นทุน (บาท)	FACTOR F &VAT 7%	รวมค่าก่อสร้าง (บาท)	หมายเหตุ	
					- Factor-F,พื้นที่ปกติ,ฝนชุก1,2	ปกติ
ก	งานสะพานและท่อเหลี่ยม	2,018,851.50	1.2455	2,514,479.54	- ดอกเบี้ยเงินกู้	7%
ข	งานทางและถนนต่อเชื่อม	67,525.44	1.3322	89,957.39	- เงินล่วงหน้าจ่าย	15%
ค	งานค่าใช้จ่ายทั่วไปตามที่กำหนด และค่าใช้จ่ายอื่น ๆ	8,579.44	1.0700	9,180.00	- เงินประกันผลงานหัก	0%
					-ราคาน้ำมันดีเซล(เฉลี่ย)	29.50
					-ดัชนีวัสดุก่อสร้าง	กุมภาพันธ์'55
สรุป	รวมค่าก่อสร้าง			2,613,616.94	-ระยะเวลาก่อสร้าง(วัน)	
	คิดเป็นเงินค่าก่อสร้างทั้งสิ้น			2,613,000.00		
	(ตัวอักษร) (สองล้านหกแสนหนึ่งหมื่นสามพันบาทถ้วน)					

7	งานป้องกันการกัดเซาะ							
	7.1 งานกล่องลวดตาข่ายบรรจุหินใหญ่ (Gabions) 1.00 ม.x1.00 ม.x 0.50 ม.							
	7.1.1 ค่ากล่องลวดตาข่ายบรรจุหินใหญ่ พร้อมลวดพันกล่อง	กล่อง	503.00	600.00	301,800.00	1.2455	747.30	375,891.90
	7.1.2 ค่าขนส่ง	LS.	1.00	4,500.00	4,500.00	1.2455	5,604.75	5,604.75
	7.1.3 ค่าถักกล่อง ประกอบ ติดตั้งกล่องเกเบี้ยน (Gabions)	กล่อง	503.00	30.00	15,090.00	1.2455	37.37	18,794.60
	7.2 งานแผ่นใยสังเคราะห์ (Geotextile)							
	7.2.1 ค่าแผ่นใยสังเคราะห์ Mat (prevention of soil suck-out)	ตร.ม.	1,400.00	90.00	126,000.00	1.2455	112.10	156,933.00
	7.2.2 ค่าปูแผ่นใยสังเคราะห์ (Geotextile)	ตร.ม.	1,379.00	20.00	27,580.00	1.2455	24.91	34,350.89
	7.2.3 ทรายรองพื้นปรับระดับ	ลบ.ม.	36.00	204.05	7,345.80	1.2455	254.14	9,149.19

ลำดับที่	รายการ	หน่วย	ปริมาณ	ค่างานต้นทุน (บาท)		Factor F	ราคากลาง (บาท)	
				ราคาต่อหน่วย	รวม		ราคาต่อหน่วย	รวม
	7.4 งานขุดแต่งงานดินปรับระดับ							
	7.4.1 งานขุดตริ่ง (Backfilling)	ลบ.ม.	472.00	19.67	9,284.24	1.2455	24.50	11,563.52
	7.4.2 งานแต่ง Slope	ลบ.ม.	233.00	19.67	4,583.11	1.2455	24.50	5,708.26
	7.4.3 งานดินถมปรับระดับ	ลบ.ม.	132.00	36.58	4,828.89	1.2455	45.56	6,014.38
	7.4.4 งานฐานราก/หินทิ้งหรือกรวดทิ้ง 45cm	ลบ.ม.	1,400.00	666.00	932,400.00	1.2455	829.50	1,161,304.20
	7.5 Partition Concrete Wall	ลบ.ม.	7.80	1,788.01	13,946.45	1.2455	2,226.96	17,370.30
8	งานบำรุงป้ายข้อมูลสะพาน,งานทาสีและงานอื่นๆที่เหลือทั้งหมด							
	8.1 งานคอนกรีตแต่งฉาบผิวสะพาน	LS.	1.00	2,000.00	2,000.00	1.2455	2,491.00	2,491.00
	8.2 งานทาสีราวสะพาน (สีพลาสติก)	ตร.ม.	82.00	48.74	3,996.68	1.2455	60.71	4,977.86
	8.3 งานทาสีสิ้นสุดสะพาน (สีน้ำมัน)	แห่ง	1.00	74.83	74.83	1.25	93.20	93.20
	8.4 งานทาสีสิ้นสุดสะพาน (สีสะท้อนแสง)	แห่ง	1.00	431.08	431.08	1.25	536.91	536.91
	8.5 งานหยอดยาง	เมตร.	68.00	12.60	856.80	1.2455	15.69	1,067.14
9	งานระบบไฟฟ้าแสงสว่าง พร้อมอุปกรณ์							

Thailand
Department of Rural Roads, Ministry of Transport

Thailand
Bridge and Bridge Maintenance Capacities in Rural Area Master Plan

Flood Preparedness Measures and Flood Damage Rehabilitation Manual
[Abridged Operation Manual, Volume 1]

November 2013

Japan International Cooperation Agency (JICA)

CHODAI Co., Ltd.
Metropolitan Expressway Co., Ltd.

Preamble

Since bridges overseen by the Department of Rural Roads were damaged by floods in many manners, such as local scour on bridge abutments or inundation of roadways due to soil and sand movement and slides around edge row abutments, which were caused by flooding, these call for actions to urgently implement preparedness and operational measures to deal with emergency circumstances sustainably.

In light of such problems, whereas references have been made to viewpoints and experiences concerning similar problems previously faced by Japan, when preparing this manual, we thereby adopt "Basic Policy for Disaster Rehabilitation to Protect Beautiful Mountains and Rivers" (June 2006) and "Draft Detailed Inspection Guideline of Facilities such as Dikes etc. in the Management of Water Resources and Floodways (May 2011)" of the Ministry of Land, Infrastructure, Transport and Tourism as a basis for considerations.

When damage rehabilitation is undertaken, the following considerations must be addressed:

(1) Adequately survey affected areas to clearly understand underlying causes of the disaster.

(2) Determine rehabilitation methods that require minimal repairs and are consistent with causes of the disaster by primarily accommodating particular characteristics of floodways.

(3) Clearly define river conservation and rehabilitation objectives and select suitable rehabilitation methods.

This manual extracts only key detailed contents regarding inspection conducted during flooding, flood damage assessment methodology and design of flood problem management measures.

Things to be considered while using the abridged manual

(1) Since this abridged manual is provisional, there may be some revision after a full version is finished.

(2) The presented structures are not permanent structures.

However, they can help mitigate flood damages like what have occurred until present.

From now on, please use the abridged and full versions of this manual. Hopefully, staff of the Department of Rural Roads will utilize accumulated knowledge and newly acquired experience in flood damage management and rehabilitation as well as management of long-term bridge maintenance of the Department of Rural Roads.

November 2012

Steps to use the abridged manual and summary details are as follows:

Step	Operation procedure, prepared documents, tables for selection of construction methods	Ref. page
Understanding of conditions of actual area	Inspect flood damages	p.1
Dealing with damaged conditions	Prepare Table A-1 and Table A-2 Table showing damage conditions (Table A-1) → Table showing damage pictures (Table A-2) →	p.4 p.7
Preparation of basic documents regarding construction and rehabilitation methods	Prepare Table A-1 and Table A-2 Table showing attributes of watercourse where damage rehabilitation is undertaken (Table A) → Table for calculating current velocity used in design (Table B) →	p.10 p.13
Select construction and rehabilitation methods	Selection of construction method by referring to Table C and Table D Construction method where slope ratio is less than 1:1.5 (Table C) → Construction method where slope ratio is greater than 1:1.5 (Table D) →	p.16 p.18
Determine construction and rehabilitation methods	Write specific construction and rehabilitation methods and amount of works in Table A ↓ Automatically calculate construction cost summary	p.12
Engagement of construction and rehabilitation works	Engage construction and rehabilitation works (※ Refer to the topics below in the engagement) ➢ Typical design → ➢ Bill of quantity →	p.20 p.31

Table of contents

Chapter 1: Method for Conducting Survey of Actual Site During Flooding

1.1 Inspection method during flooding

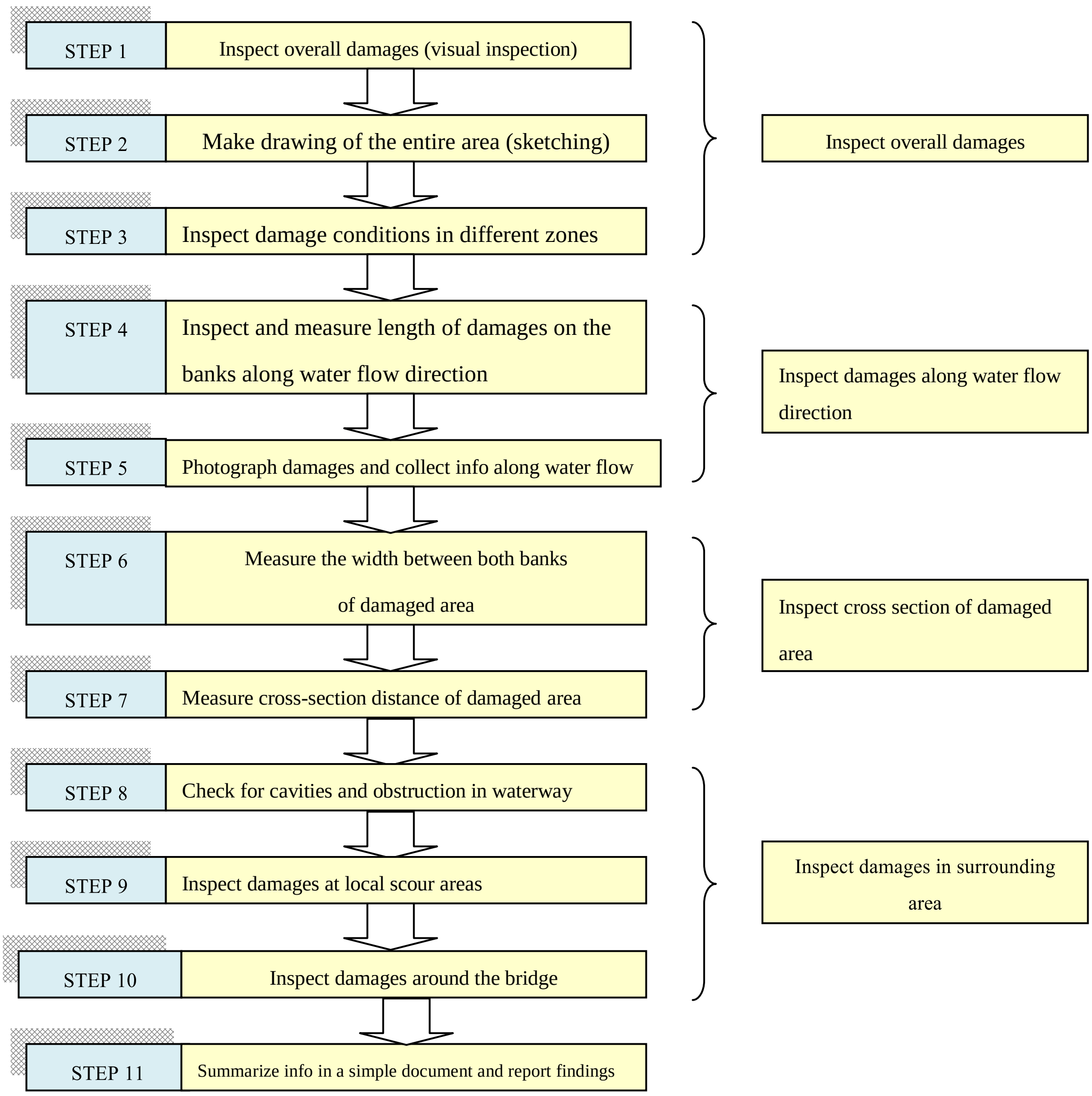
Objectives:

When scrutinizing measures to repair flood damages, one cannot only rely on photography. It is necessary to conduct a survey to examine damage conditions at an actual site so that suitable repair measures can be determined.

Therefore, simple inspection methods for assessment of flood damages under a bridge and around its surrounding area are compiled by collecting methods on how to reach a conclusion and prepare basic documents for determination of repair measures. To this end, this “abridged operation manual” was developed to enable officials of the Department of Rural Roads to use it in actual works efficiently.

Overall operational steps

Overall operational steps are presented below. Details of each step are described in the next page.

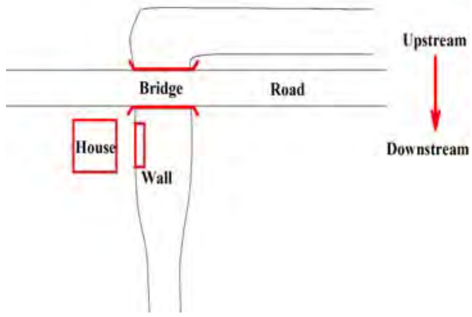


STEP 1 | Inspect overall damages (visual inspection)

- ✓ Bridge
- ✓ Form of river, water flow direction
- ✓ Check whether there are houses and public structures

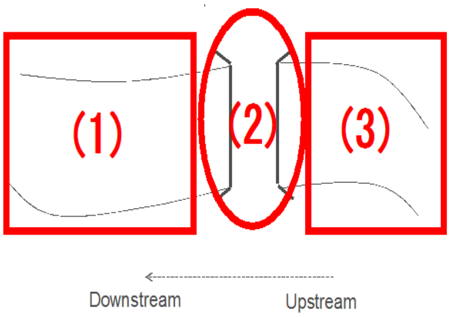
STEP 2 | Make drawing of the entire area (sketching)

- ✓ Sketch the entire area
- ✓ Specify water flow direction
- ✓ Indicate if any houses are in the vicinity
- ✓ Note other special structures



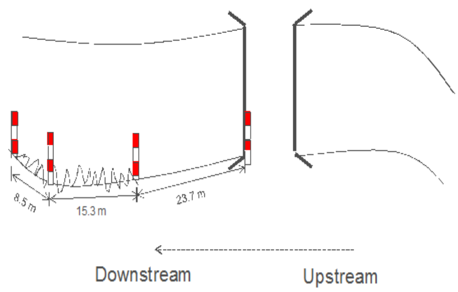
STEP 3 | Inspect damage conditions in different zones

- ✓ Inspect damage conditions in three zones
- ✓ (1) Downstream zone of the bridge
- ✓ (2) Under the bridge
- ✓ (3) Upstream zone of the bridge



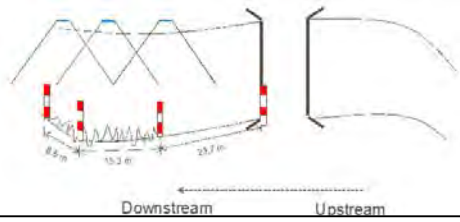
STEP 4 | Inspect and measure length of damages on the banks along water flow direction

- ✓ Plant poles to mark the beginning and end points
- ✓ Plant poles to mark spots where topography changes
- ✓ Measure distances by referring to the bridge’s position



STEP 5 | Photograph damages and collect info along water flow direction

- ✓ Take pictures along the length of damaged area
- ✓ If damages extend over a long distance, take pictures and form overlapping photos



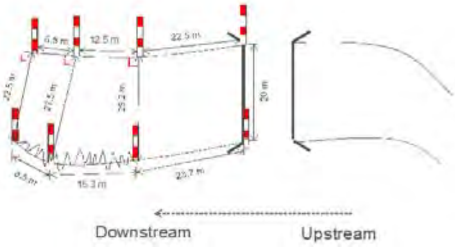
STEP 6 - Continue in the next page

STEP 5 From the previous page

STEP 6 Measure the width between both banks of damaged area

✓ Use a tape to measure the river's width at every spot where the width or water flow changes

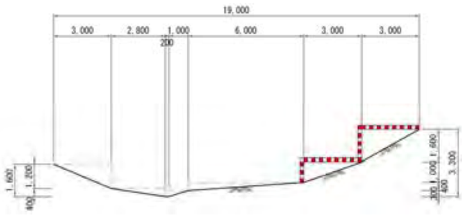
Make measurement across the channel; specify distances from the bridge



STEP 7 Measure cross-section distance of damaged area

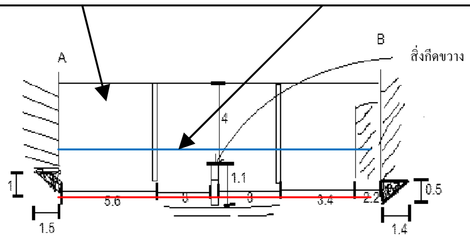
✓ Use poles or staffs to measure vertical and horizontal distances of the banks along cross section of waterway

Draw cross section view from upstream facing toward downstream direction



STEP 8 Check for cavities and obstruction in waterway

✓ Measure distances of obstruction in waterway and scours between the original ground level and abutments and girders

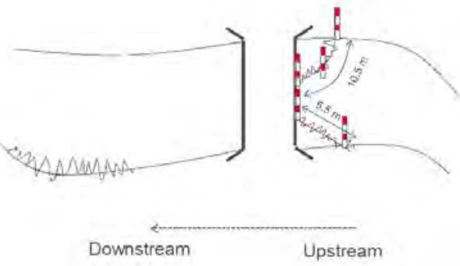


If a cavity is present, measure its width and depth

STEP 9 Inspect damages at local scour areas

✓ Measure length of damages at local scour areas

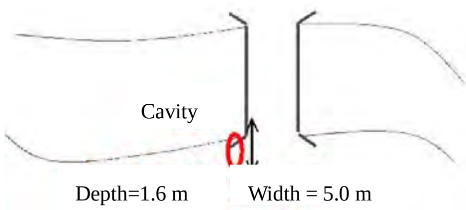
Record distances of scour positions



STEP 10 Inspect damages around the bridge

✓ Measure damages e.g. washed-away soil behind edge row abutments

Record cavity's distance from the bridge as well as its width and depth



STEP 11 Summarize info in a simple document and report findings

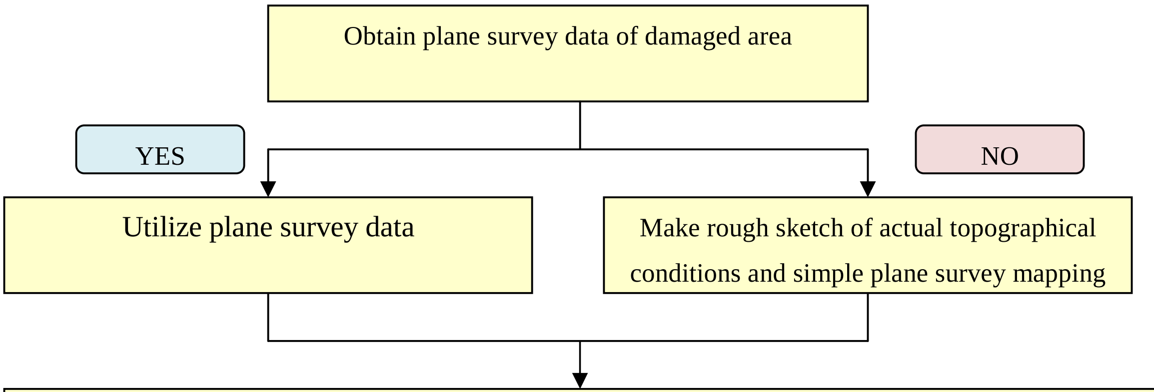
1.2 Table showing damage conditions (Table A-1)

When contemplating rehabilitation measures, it is necessary that one must understand topography of damaged conditions where detailed aerial and measurement surveys are conducted if such information will be used.

If measurement survey data are not available, instruments such as measuring tape, staff or pole or laser-guided measuring device must be used at the actual site. In addition, overall topographical conditions at the actual site must also be sketched.

Moreover, measurement survey must include cross sections of upstream, midstream and downstream areas which represent three positions marking the perimeter of damaged area. Such data must be input in Table B and written down in an itemized list.

【Summary details of the preparation procedure (Table A-1)



- ✓ Note the length and depth of damages, using the scope which can be inspected and measured.
- ✓ Note flow directions on a plane survey map.
- ✓ Note cross sections of damages whereby such data must be input in Table B.
  - Make cross section survey and measurement of upstream, midstream and downstream zones of damaged area.
  - In case there is any substantial pattern change aside from three cross sections, inspection and measurement must be undertaken separately.
- ✓ Note directions and assign numbers for used pictures in Table A-2

Table for refurbishing damage conditions (Table A-1)

Bridge Name			Inspection Date	
Location			Route Number	
Latitude	N		Province	
Longitude	E		Main Inspector	

Make survey plane drawing, note length of damages and damage conditions

↓

Note cross sections of damages (upstream, midstream, downstream)

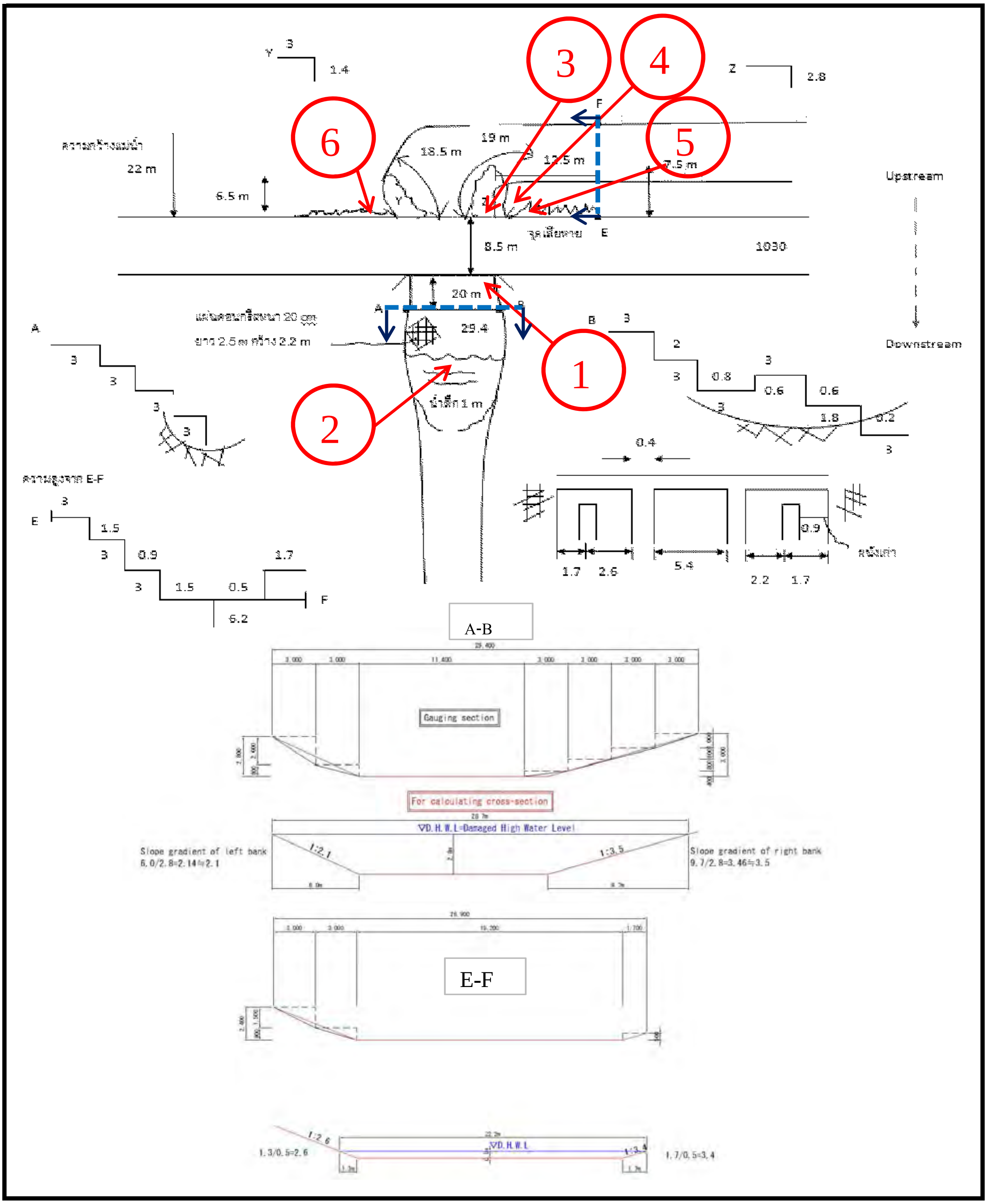
(※at least note upstream and downstream)

↓

Others: write down needed information

Table showing damage restoration (Table A-1)

Bridge Name	Sample (Temporary number : 1030-2)	Inspection Date	26/01/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N 15.076	Province	Lop Buri
Longitude	E 100.675	Main Inspector	(name)



1.3 Table showing damage pictures (Table A-2)

The documentation of damage pictures is required, so conditions at the actual site are perceived correctly. Moreover, the pictures also illustrate positions and the extent of damages and are used when reviewing decisions and determining the necessity of construction and damage rehabilitation as well as construction and rehabilitation methods. Therefore, damage pictures are required as supplementary information.

When taking pictures, an aim of each picture thereby must be defined so as to know what picture will be taken and think about picture's composition that can show such details precisely and adequately.

General points of consideration when taking pictures are as follows:

- ✓ Plant poles in land survey zone at beginning and ending points so that precise distances can be determined.
- ✓ Be flexible so that cross sectional topography can be examined easily.
- ✓ Note water flow direction, beginning and ending points as well as distances on pictures.
- ✓ Take pictures of structural damages of embankment retaining wall and indicate these damages by using staff or pole, etc.
- ✓ Take pictures of flow directions at upstream and downstream areas, including beginning and end points, so that overall conditions around the bridge can be perceived.

Table showing pictures of damage conditions (Table A-2)

Bridge Name			Inspection Date	
Location			Route Number	
Latitude	N		Province	
Longtitude	E		Main Inspector	

Picture No.	1	Position		Picture No.	2	Position		Picture No.	3	Position	
Description				Description				Description			
Paste picture				Paste picture				Paste picture			
Picture No.	4	Position		Picture No.	5	Position		Picture No.	6	Position	
Description				Description				Description			
Paste picture				Paste picture				Paste picture			

Table showing pictures of damaged conditions (Table A-2)

Bridge Name	Sample (Temporary number : 1030-2)	Inspection Date	26/01/2012
Location	Thalung Lek, Khok Samrong, Lop Buri	Route Number	1030
Latitude	N 15.076	Province	Lop Buri
Longitude	E 100.675	Main Inspector	(name)

Picture No.	1	Position	Downstream	Picture No.	2	Position	Downstream	Picture No.	3	Position	Under girder
Description	Scour conditions at downstream bank			Description	Conditions of downstream bank			Description	Ruins of pile structure (clogging waterway)		
											
Picture No.	4	Position	Under girder	Picture No.	5	Position	Upstream	Picture No.	6	Position	Road on upstream bank
Description	Scour conditions, depth 2 m			Description	Scour conditions at upstream bank			Description	Damage conditions at top edgeof embankment		
											

Chapter 2: Documents Required for Planning of Post-Flood Construction and Rehabilitation Methods

2.1 Table showing river attributes river where rehabilitation is undertaken (Table A)

Prepare Table A when drafting a construction and rehabilitation plan. Table A will be presented at a meeting and while conducting damage assessment review.

【Additional chapter】

- ✓ Table A is a basic document prepared for understanding of causes of damages and river attributes, such as conditions of the river where damages exist and of surrounding area, which are observed while conducting a field survey and for drafting of a construction and rehabilitation plan.
- ✓ When preparing Table A, field staff should make a careful observation of the actual site and then prepare Table A-1 and Table A-2 successively.

Table showing river attributes where rehabilitation is undertaken (Table A)

Bridge Name		
Location		
Latitude	N	
Longtitude	E	

Inspection Date	
Route Number	
Province	
Main Inspector	

Present conditions before rehabilitation						
River and road conditions	Length of damage					
	Damaged facilities	☐ Dike	· ☐ Embankment	· ☐ Foundation reinforcement	· ☐ Others	
	Channel variation	☐ Upward trend	· ☐ Downward	· ☐ Unchanged		
	River conditions	☐ Straight line	· ☐ Bend			
Existing embankment	Position	Year of construction	Type		Slope	Detailed structure
	Related position	None				
	Upstream	None				
	Downstream	None				
Attributes of river and road	Cross section	☐ Single cross section	· ☐ Multiple cross sections			
	Structure	☐ Adjacent to mountain	· ☐ Deep excavation	· ☐ Dike		
Channel materials	Soil condition	☐ Clay	· ☐ Sand	· ☐ Gravel	· ☐ Stone	· ☐ Others
	Diameter of sample particles					

General example	
Fill out each item by filling it with colors below	
(yellow)	Manually key in numbers and text in the topic
(green)	Choose item which is within the scope
(pink)	Automatically calculated by excel program

Determining construction and rehabilitation methods				
(1) Desired goal of river environment	Natural environment that stimulates vitality of plants and animals			
(2) Scenery	☐ Vegetation	· ☐ Stone	· ☐ Concrete	· ☐ Others
(3) Inspection topics (※Calculation method refers to Table B)	Slope of refurbished embankment			
	Design current velocity			
(4) Conditions of surrounding areas				
(5) Basis for selection of construction and rehabilitation methods				
(6) Others				

Determining construction and rehabilitation methods		
Slope in construction and rehabilitation methods	☐ Slope ratio less than 1:1.5 ⇒ set in (Table C)	
	☐ Slope ratio greater than 1:1.5 ⇒ set in (Table D)	
Construction method		
Rehabilitation area		
Unit price of construction method		
Estimated construction cost		

Table showing river attributes where rehabilitation is undertaken (Table A)

Bridge Name	Sample (Temporary number : 1030-2)	
Location	Thalung Lek, Khok Samrong, Lop Buri	
Latitude	N	15.076
Longtitude	E	100.675

Inspection Date	26/01/2012
Route Number	1030
Province	Lop Buri
Main Inspector	(name)

Present conditions before rehabilitation

River and road conditions	Length of damage	50(m)			
	Damaged facilities	☐ Dike	☐ Embankment	☐ Foundation reinforcement	☐ Others
	Channel variation	☐ Upward trend	☐ Downward	☑ Unchanged	
	River conditions	☑ Straight line	☐ Bend		
Existing embankment	Position	Year of construction	Type	Slope	Detailed structure
	Related position	None			
	Upstream	None			
	Downstream	None			
Attributes of river and road	Cross section	☑ Single cross section	☐ Multiple cross sections		
	Structure	☐ Adjacent to mountain	☑ Deep excavation	☐ Dike	
Channel materials	Soil condition	☑ Clay	☐ Sand	☐ Gravel	☐ Rock ☐ Others
	Diameter of sample particles	0.5(mm)			

General example

Fill out each item by filling it with colors below

Color	Meaning
(yellow)	Manually key in numbers and text in the topic
(green)	Choose item which is within the scope
(pink)	Automatically calculated by excel program

Determining construction and rehabilitation methods

(1) Desired goal of river environment	Natural environment that stimulates vitality of plants and animals			
(2) Scenery	☐ Vegetation	☐ Stone	☑ Concrete	☑ Others
(3) Inspection topics (※Calculation method refers to Table B)	Slope of refurbished embankment	1:1.0		
	Design current velocity	2.3(m/s)		
(4) Conditions of surrounding areas	Paddy field			
(5) Basis for selection of construction and rehabilitation methods				
(6) Others				

Determining construction and rehabilitation methods

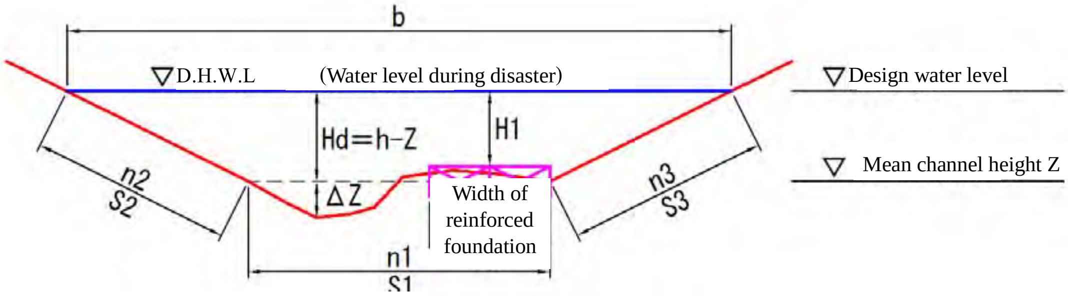
Slope in construction and rehabilitation methods	☐	Slope ratio less than 1:1.5 ⇒ set in (Table C)
	☑	Slope ratio greater than 1:1.5 ⇒ set in (Table D)
Construction method	D-2	Multiple-layered wire mesh boxes
Rehabilitation area	500 (m^2)	
Unit price of construction method	13500 (yen /m^2)	
Estimated construction cost	6,750,000 (yen)	

2.2 Table for calculating design current velocity (Table B)

Prepare Table B for calculating design current velocity, whereby the objective is to determine embankment.

【Additional chapter】

- ✓ Current velocity is calculated by using the Manning's equation, whereby adjusted coefficient is determined by taking account of topographical conditions and mean current velocity in open water per cross sectional area, in order to choose a suitable embankment construction method.
- ✓ Detailed description of longitudinal slope, roughness coefficient, design water level, mean current velocity, adjusted coefficient, etc. Please refer to the full version of this manual.
- ✓ Since design current velocity derived from the calculation from Table B is not an absolute value, it should be applied by sufficiently taking the actual site and other conditions into consideration.
- ✓ In the abridged manual, only the formula for calculating current velocity per cross section of straight waterway is mentioned. As for the calculation method to obtain current velocity at a bend of a large river, please refer to the full version of this manual.



Determination of roughness coefficient

Roughness coefficient of channel: n1	
Soil type and characteristic	Roughness coefficient
Rock	0.035 ~ 0.050
Large, round stone (10cm~20cm) Gravel	0.030
Pebble (5cm~10cm)	0.035
Sandy soil Sedimentary rock (not over 2cm)	0.020

Roughness coefficient of embankment : n2, n3	
Type of structure	Roughness coefficient
Concrete block	0.024
Wire mesh box	0.032
Grass - approx. height 20cm	0.032
Colored stone - approx. 30cm	0.025

Determination of adjusted coefficient

α1|**If channel is not located where deep excavation exists due to rocks, etc., choose stable channel : α 1= 1 If channel has rocks and soil all over, choose unstable channel : α 1= 1 + (△Z/2Hd)**

α2|**Select by comparing between bw (width of matting to prevent bank sloping) and H1 (water depth)**

Table for calculating design current velocity (Table B)

【Reviewed position】

Province name	
Road name	
Bridge name	

【Example】

(yellow)	Input number, text
(white)	Input automatic calculation
(red)	Automatically generate review outcome

River and road		Position		No.1	No.2	No.3	Note
		Min waterway width	[b(m)]				
		Longitudinal slope	[Ie]				
		Left bank slope					
		Right bank slope					
Hydraulic radius		Channel radius	[Rd(m)]				
Design water depth		Design water position	[h(m)]				
		Present mean height of water surface	[Z(m)]				
		Design water depth	[Hd(m)]				
Roughness coefficient	Roughness coefficient of each section	Riverbed	[n_1]				
		Left embankment	[n_2]				
		Right embankment	[n_3]				
	Wetted perimeter	Channel	[S_1]				
		Left embankment	[S_2]				
		Right embankment	[S_3]				
		Total	[S]				
	Total roughness coefficient	$\{n_1^{3/2} \times S_1\}$					
		$\{n_2^{3/2} \times S_2\}$					
		$\{n_3^{3/2} \times S_3\}$					
		Total					
		Total roughness coefficient	N				
Mean current velocity [Vm]		$Vm=1/N \cdot Rd^{2/3} \cdot Ie^{1/2}$					
Maximum current velocity [Vc]		$Vc=(g \cdot Rd)^{1/2}$					If Vm>Vc Re-validate factors
Present max scour depth (actual value)			[⊿Z]				
Adjusted coefficient	Stable channel	a1=1					Position where no rock protrudes and excavated channel is deep
	Unstable channel	{⊿Z/2Hd}					
		a1 = 1+{⊿Z/2Hd}					Upper limit 2
	Foundation reinforcement	bw/H1＞1 → α2 = 0.9 bw/H1≦ 1 → α2 = 1.0					Adjusted coefficient in case foundation is reinforced
	α	plied adjusted coefficient a = a1 x					
Principal current velocity [Vo]		Vo = a・Vm					
Design current velocity [V_D]		V_D = meanVo					

Table for calculating design current velocity (Table B)

【Reviewed position】

Province name	
Road name	
Bridge name	

【Example】

(yellow)	Input number, text
(white)	Input automatic calculation
(red)	Automatically generate review outcome

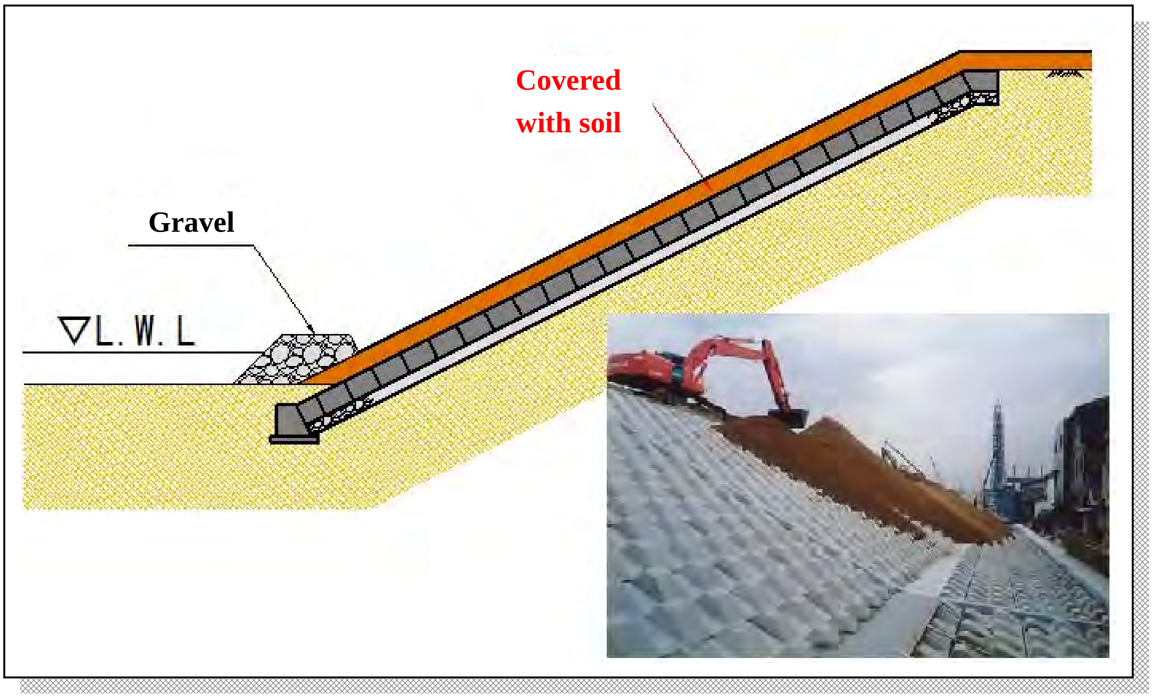
		Location		No.1	No.2	No.3	Note
River and road		Min waterway width	[b(m)]	13	13	13	
		Longitudinal slope	[Ie]	1/300	1/300	1/300	
		Left bank slope		2.0	2.0	2.0	
		Right bank slope		2.0	2.0	2.0	
Hydraulic radius		Channel radius	[Rd(m)]	1.3	1.3	1.3	
Design water depth		Design water position	[h(m)]	3.0	3.0	3.0	
		Present mean height of water surface	[Z(m)]	0.9	1.0	1.0	
		Design water depth	[Hd(m)]	2.1	2.0	2.0	
Roughness coefficient	Roughness coefficient of each section	Riverbed	[n_1]	0.030	0.030	0.030	
		Left embankment	[n_2]	0.024	0.032	0.024	
		Right embankment	[n_3]	0.032	0.032	0.032	
	Wetted perimeter	Channel	[S_1]	4.6	5.0	5.0	
		Left embankment	[S_2]	4.7	4.5	4.5	
		Right embankment	[S_3]	4.7	4.5	4.5	
		Total	[S]	14.0	14.0	14.0	
	Total roughness coefficient	$\{n_1^{3/2} \times S_1\}$		0.024	0.026	0.026	
		$\{n_2^{3/2} \times S_2\}$		0.017	0.026	0.017	
		$\{n_3^{3/2} \times S_3\}$		0.027	0.026	0.026	
		Total		0.068	0.078	0.069	
		Total roughness coefficient	N	0.029	0.031	0.029	
Mean current [Vm]		$Vm=1/N \cdot Rd^{2/3} \cdot Ie^{1/2}$		2.4	2.2	2.4	
Maximum current velocity [Vc]		$Vc=(g \cdot Rd)^{1/2}$		3.6	3.6	3.6	If Vm>Vc validation of factors is required
Present max scour depth (actual value)			[⊿Z]	0.5	0.5	0.5	
Adjusted coefficient	Stable channel	a1=1					Position where no rock protrudes and excavated channel is
	Unstable channel	{⊿Z/2Hd}		0.12	0.13	0.13	
		a1 = 1+{⊿Z/2Hd}		1.12	1.13	1.13	Upper limit 2
	Foundation reinforcement	bw/H1＞1 → α2 = 0.9 bw/H1≦ 1 → α2 = 1.0		1.00	1.00	1.00	Adjusted coefficient in case foundation is reinforced
	α	plied adjusted coefficient a = a1 x		1.12	1.13	1.13	
Principal [Vo]		V o = a ・ V m		2.7	2.5	2.7	
Design current [V_D]		V_D = meanVo		2.6 (m/s)			

Chapter 3: Design of Post-Flood Construction and Rehabilitation Methods

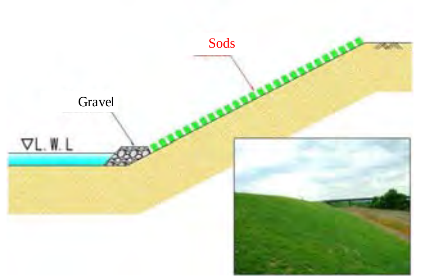
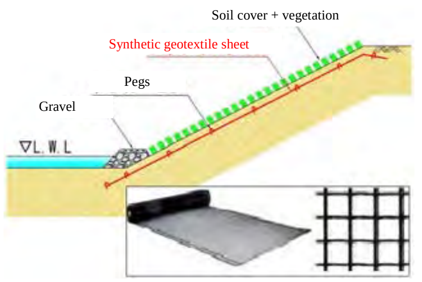
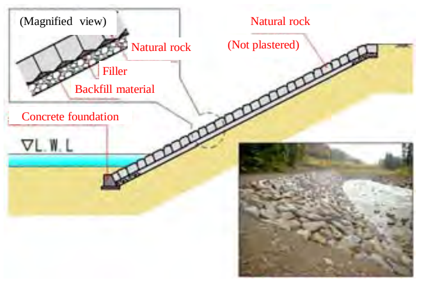
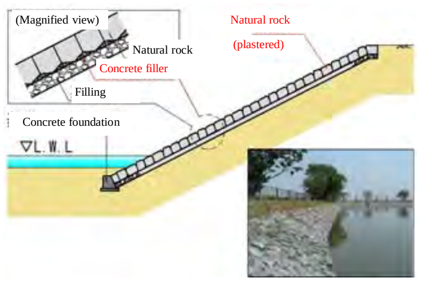
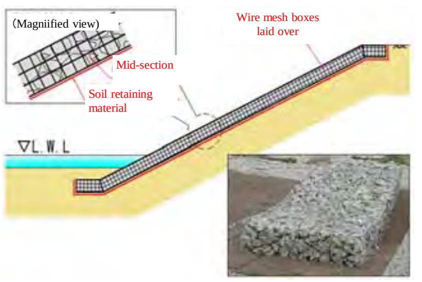
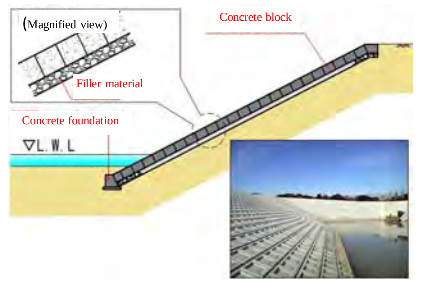
3.1 Construction method where slope ratio is less than 1:1.5 (Table C)

In case slope ratio of embankment is less than 1:1.5, a practical construction method must be selected from Table C.

However, if surrounding environment and nearby landscape must be taken into consideration, top edge of embankment may be covered with soil as a standard construction measure.



Construction method where slope ratio is less than 1:1.5 (Table C)

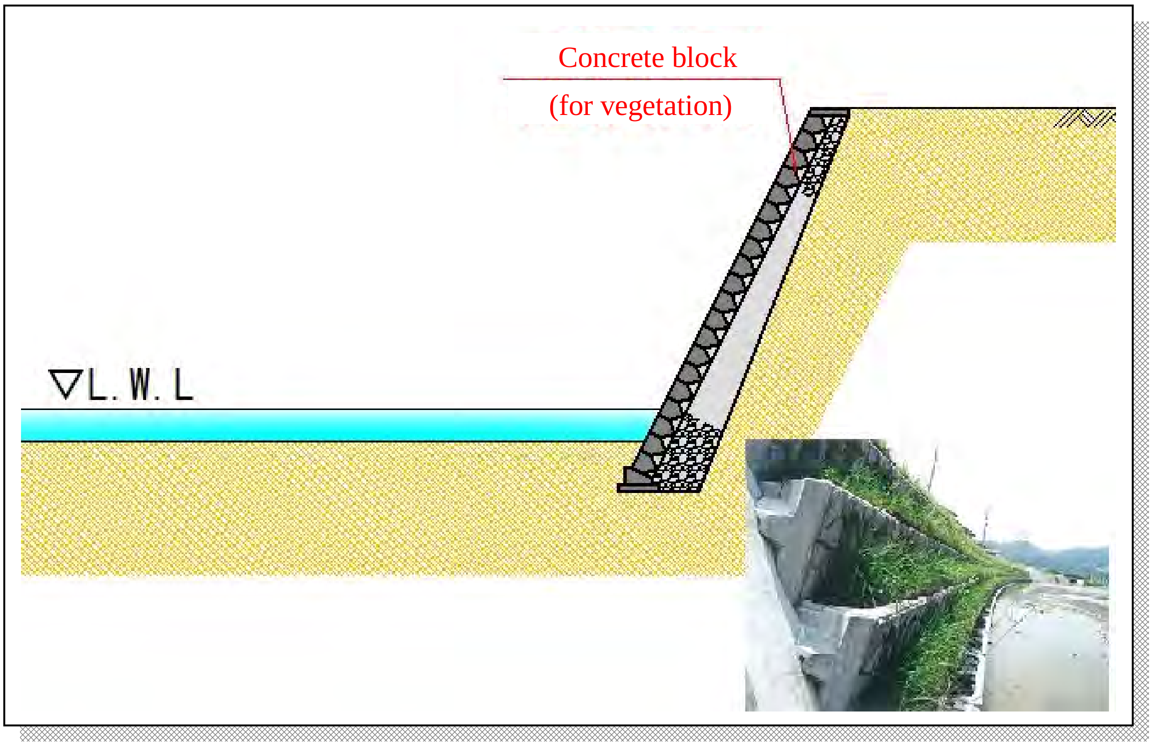
Designation of embankment construction method			Graphic overview	Design current velocity (m/s) 2	3	4	5	6	Plantable or not	Unit construction cost (yen/m²)
Vegetation	C-1	Sodding							○	900
Sheeting	C-2	Synthetic geotextile sheet							○	2,500
Rock	C-3	Natural rock (not plastered with cement)							△	9,900
	C-4	Natural rock (plastered with cement)							△	16,200
Wire mesh box	C-5	Wire mesh box							○	11,000
Concrete	C-6	Concrete block							△	13,300

○ = Plantable △ = Not plantable

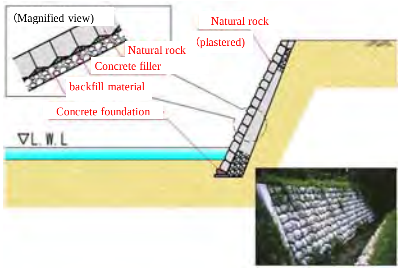
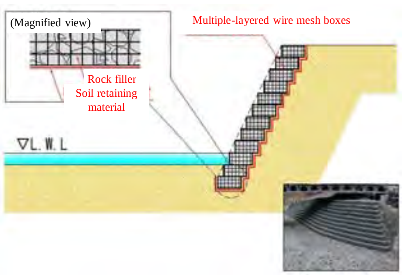
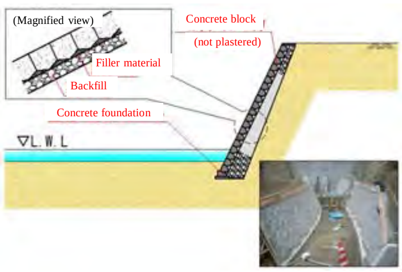
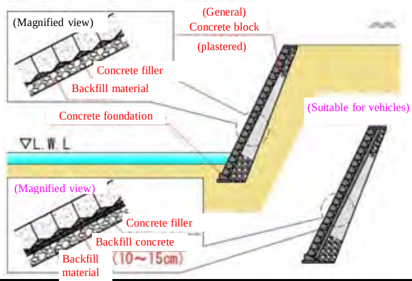
3.2 Construction method where slope ratio is greater than 1:1.5 (Table D)

In case slope ratio of embankment is greater than 1:1.5, a practical construction method must be selected from Table D.

However, if surrounding environment and nearby landscape must be taken into consideration, products suitable for vegetation may be selected as a standard construction measure.



Construction method where slope ratio is greater than 1:1.5 (Table D)

Designation of construction method for retaining wall			Graphic overview	Design current velocity (m/s) 2	3	4	5	6	For vegetation	Unit construction cost (yen/m²)
Rock	D-1	Natural rock (plastered with cement)							△	16,200
Wire mesh box	D-2	Multiple-layered wire mesh boxes							○	13,500
Concrete	D-3	Concrete block (not plastered with cement)							△	15,400
	D-4	Concrete block (plastered with cement)							△	21,700

○ = Plantable   △ = Note plantable

3.3 Standard drawing

The construction and rehabilitation methods of Table C and D are elaborated in these chapters.

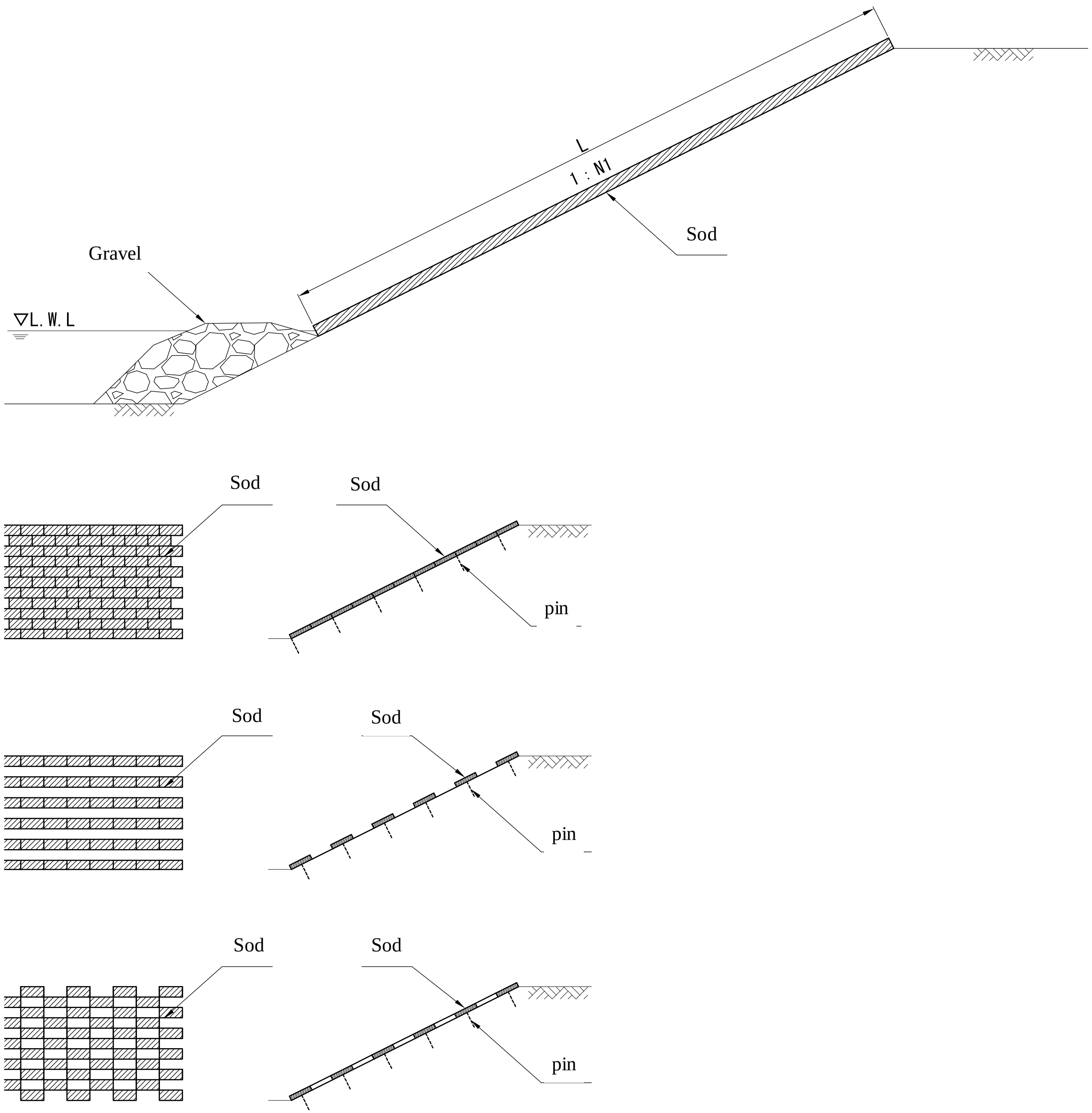
Construction method where slope ratio is less than 1:1.5 (Table C)

Designation of method		Ref. page
C-1	Sodding	p.21
C-2	Synthetic geotextile sheet	p.22
C-3	Natural rock (not plastered with cement)	p.23
C-4	Natural rock (plastered with cement)	p.24
C-5	Stacking wire mesh boxes	p.25
C-6	Laying concrete boxes	p.26

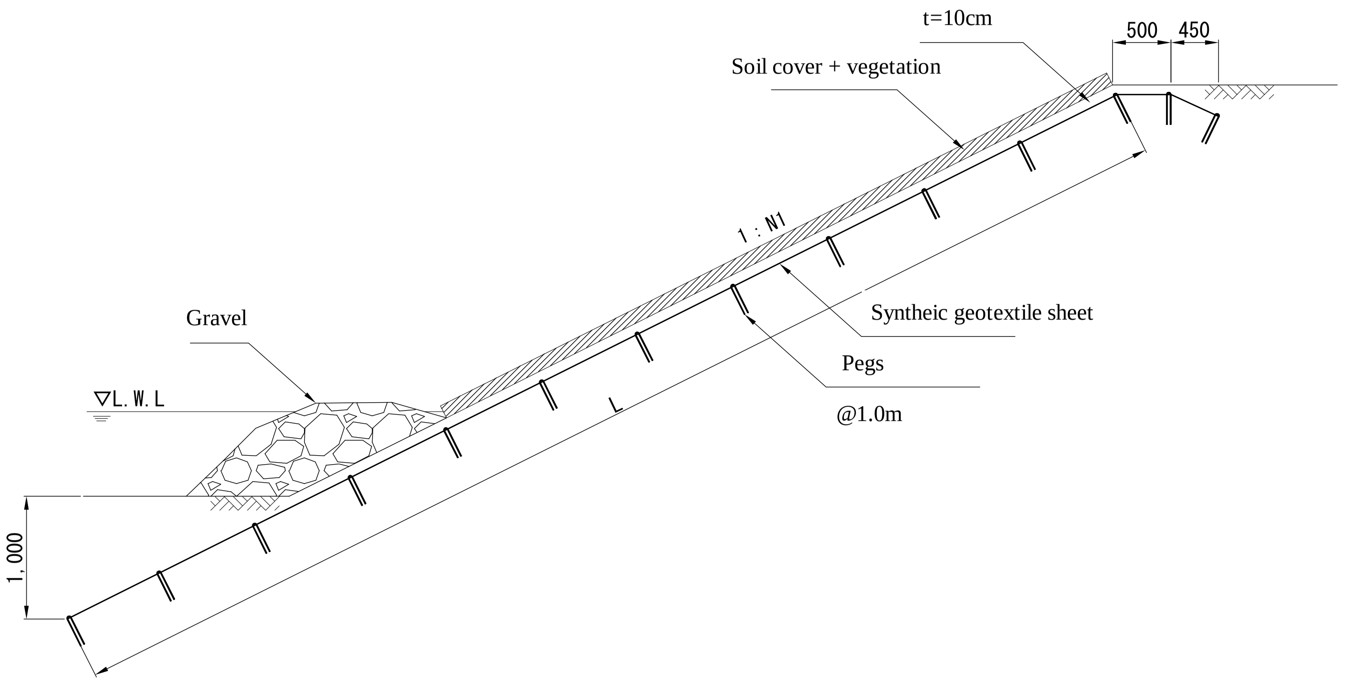
Construction method where slope ratio is greater than 1:1.5 (Table D)

Designation of method		Ref. page
D-1	Natural rock (plastered with cement)	p.27
D-2	Multiple-layered wire mesh boxes	p.28
D-3	Stacking wire mesh boxes (not plastered with cement)	p.29
D-4	Stacking wire mesh boxes (plastered with cement)	p.30

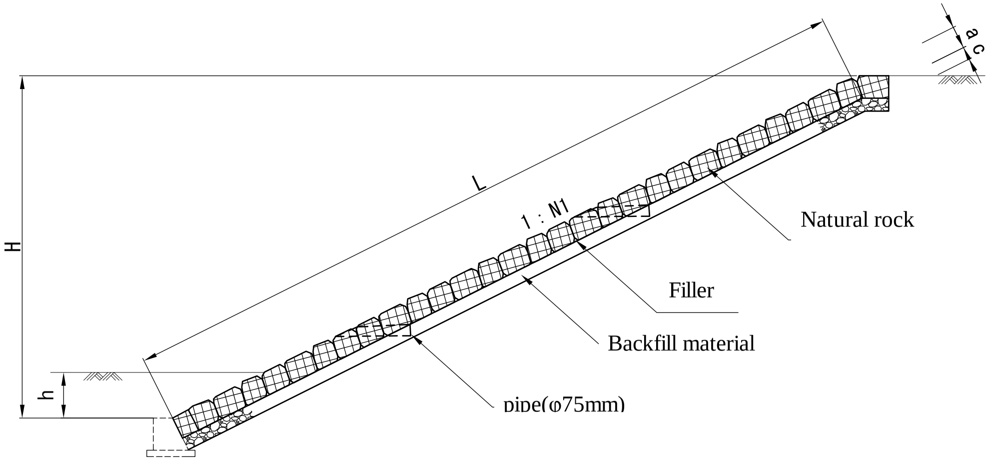
【C-1】Sodding



【C-2】 Geotextile

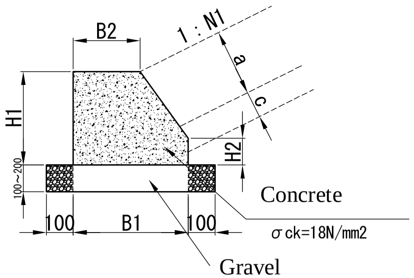


【C−3】 Natural rock(not plastered with cement)



(mm)

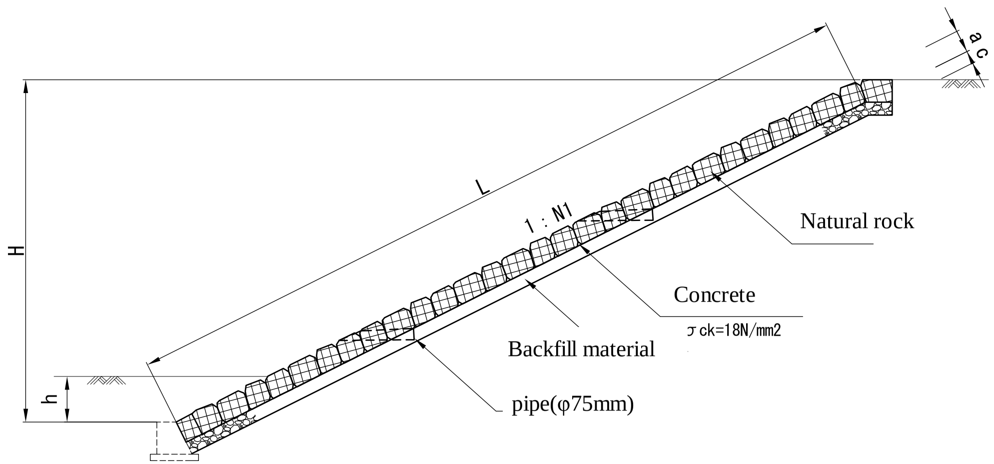
H (m)	L N1 1:1.0	L N1 1:1.5	L N1 1:2.0	a	c
1.00	1414	1803	2236	350	200
2.00	2828	3606	4472	350	200
3.00	4242	5409	6708	350	200
4.00	5656	7212	8944	350	200
5.00	7070	9015	11180	350	200



(mm)

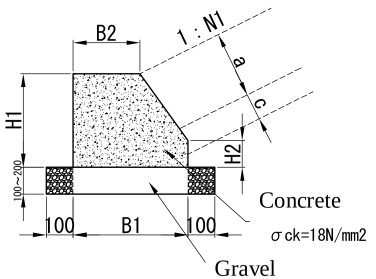
	B1	B2	H1	H2
1:1.0	700	300	500	100
1:1.5	560	300	500	100
1:2.0	550	300	500	0

【C-4】 Natural rock(plastered with cement)



(mm)

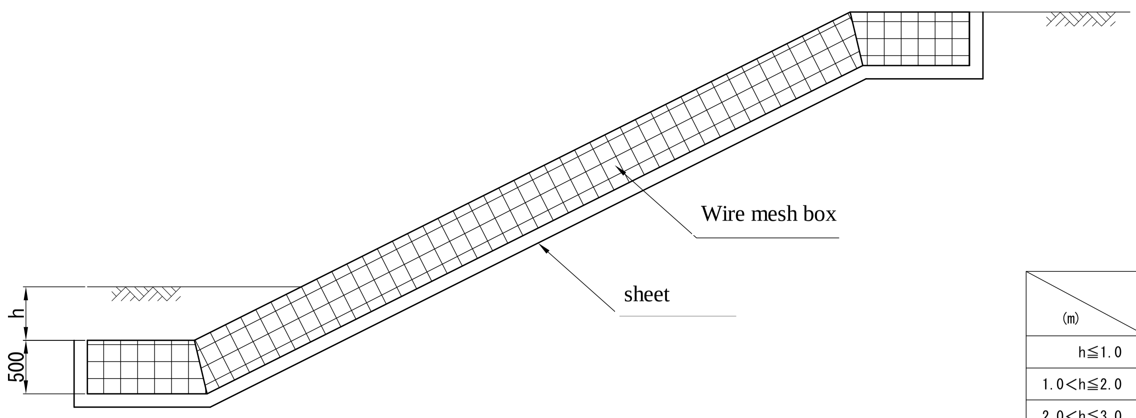
H	L				
	N1				
(m)	1:1.0	1:1.5	1:2.0	a	c
1.00	1414	1803	2236	350	200
2.00	2828	3606	4472	350	200
3.00	4242	5409	6708	350	200
4.00	5656	7212	8944	350	200
5.00	7070	9015	11180	350	200



(mm)

	B1	B2	H1	H2
1:1.0	700	300	500	100
1:1.5	560	300	500	100
1:2.0	550	300	500	0

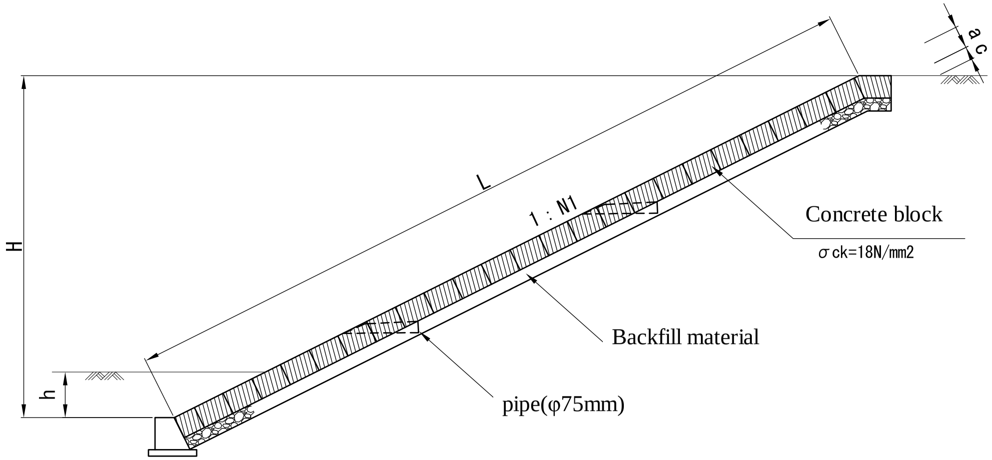
【C-5】 Wire mesh box



(cm)

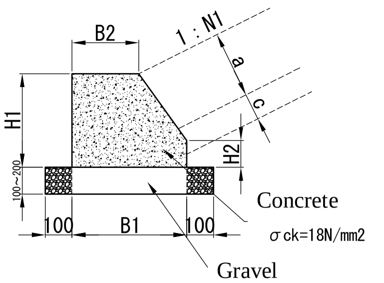
(m)	(m/s) 1.0	2.0	3.0	4.0	5.0	6.0	6.5
h≦1.0	5～15	5～15	5～15	5～15	15～20	—	—
1.0<h≦2.0	5～15	5～15	5～15	5～15	5～15	15～20	15～20
2.0<h≦3.0	5～15	5～15	5～15	5～15	5～15	5～15	15～20
3.0<h≦4.0	5～15	5～15	5～15	5～15	5～15	5～15	5～15
4.0<h≦5.0	5～15	5～15	5～15	5～15	5～15	5～15	5～15

【C-6】 Concrete block



(mm)

H	L				
	N1				
(m)	1:1.0	1:1.5	1:2.0	a	c
1.00	1414	1803	2236	350	200
2.00	2828	3606	4472	350	200
3.00	4242	5409	6708	350	200
4.00	5656	7212	8944	350	200
5.00	7070	9015	11180	350	200



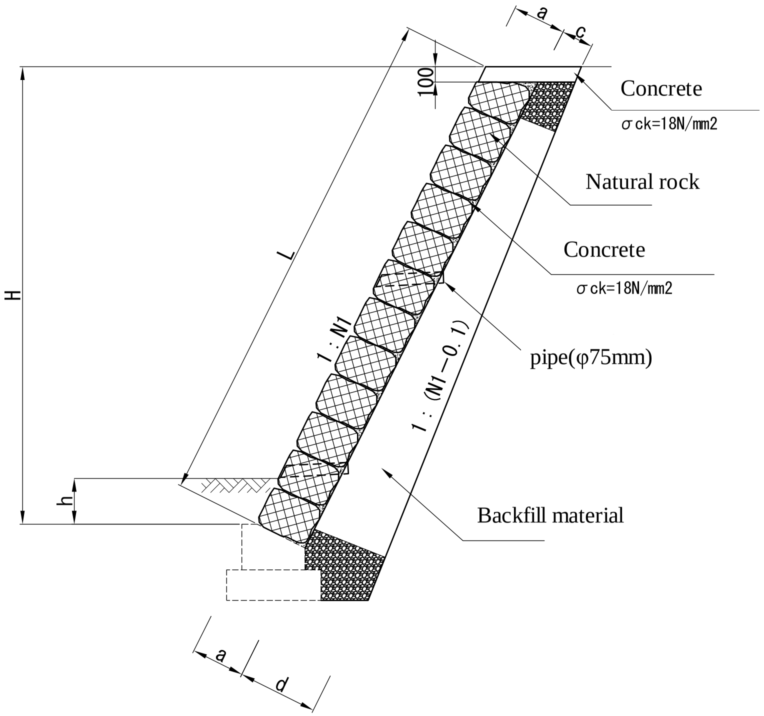
(mm)

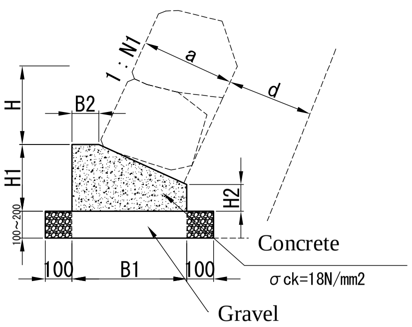
	B1	B2	H1	H2
1:1.0	700	300	500	100
1:1.5	560	300	500	100
1:2.0	550	300	500	0

【D-1】 Natural rock(plastered with cement)

(mm)

H	L				(mm)							
	N1				U1				U2			
	1:0.3	1:0.4	1:0.5	a	c	d			c	d		
(m)						1:0.3	1:0.4	1:0.5		1:0.3	1:0.4	1:0.5
1.00	1044	1077	1118	350	200	339	335	300	300	439	435	430
1.50	1566	1616	1677	350	200	387	381	374	300	487	481	474
2.00	—	2154	2236	350	200	—	427	419	300	—	527	519
2.50	—	2693	2795	350	200	—	474	454	300	—	574	564
3.00	—	3231	3354	350	200	—	520	509	300	—	620	609
3.50	—	—	3913	350	200	—	—	553	300	—	—	653
4.00	—	—	4473	350	200	—	—	598	300	—	—	698
4.50	—	—	5031	350	200	—	—	643	300	—	—	743
5.00	—	—	5590	350	200	—	—	687	300	—	—	787

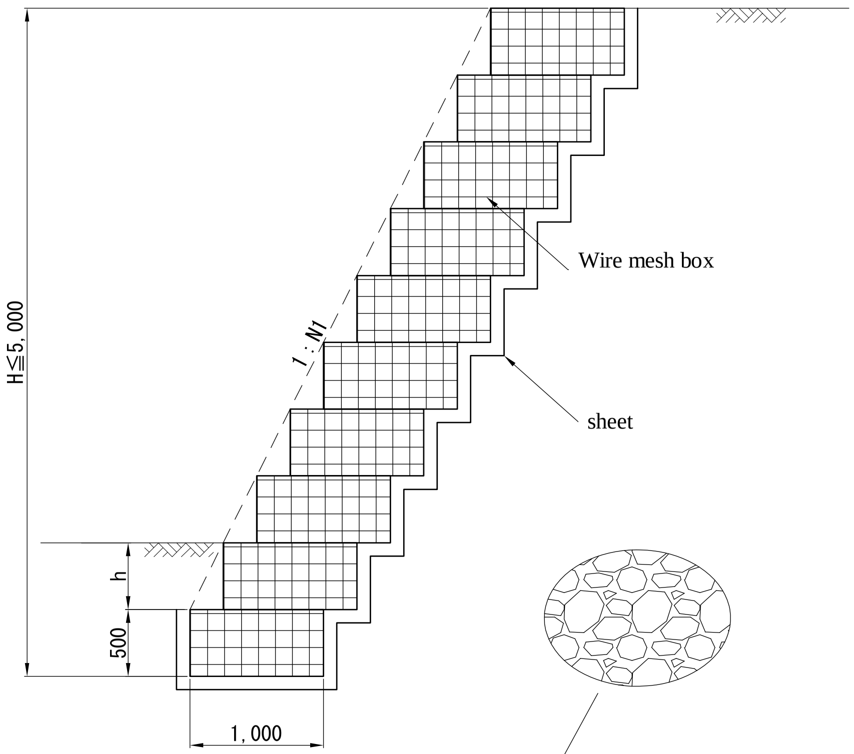


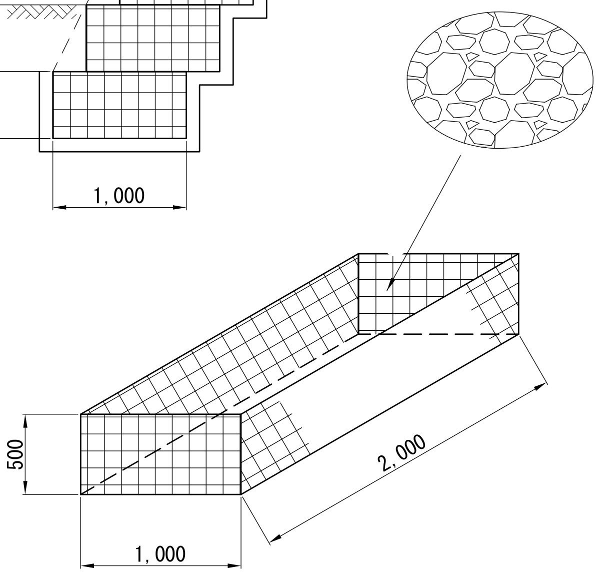


(mm)

a	B1	B2	H1	H2
350	430	100	250	100

【D-2】Multiple-layered wire mesh boxes

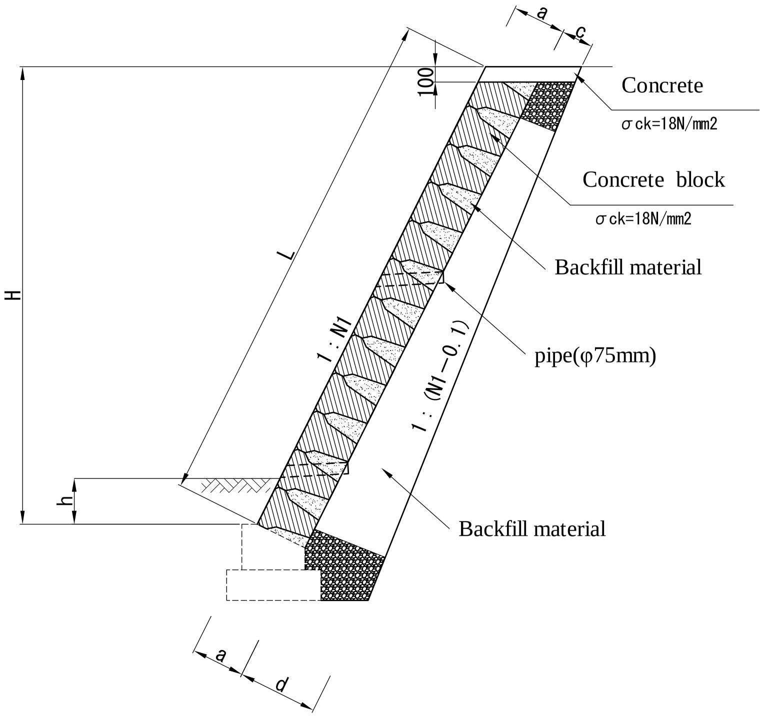




(cm)

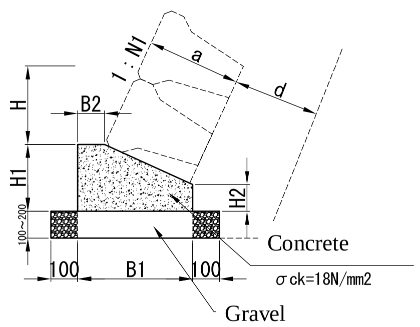
(m)	(m/s) 1.0	2.0	3.0	4.0	5.0	6.0	6.5
h≦1.0	5～15	5～15	5～15	5～15	15～20	—	—
1.0<h≦2.0	5～15	5～15	5～15	5～15	5～15	15～20	15～20
2.0<h≦3.0	5～15	5～15	5～15	5～15	5～15	5～15	15～20
3.0<h≦4.0	5～15	5～15	5～15	5～15	5～15	5～15	5～15
4.0<h≦5.0	5～15	5～15	5～15	5～15	5～15	5～15	5～15

【D−3】 Concrete block(not plastered with cement)



(mm)

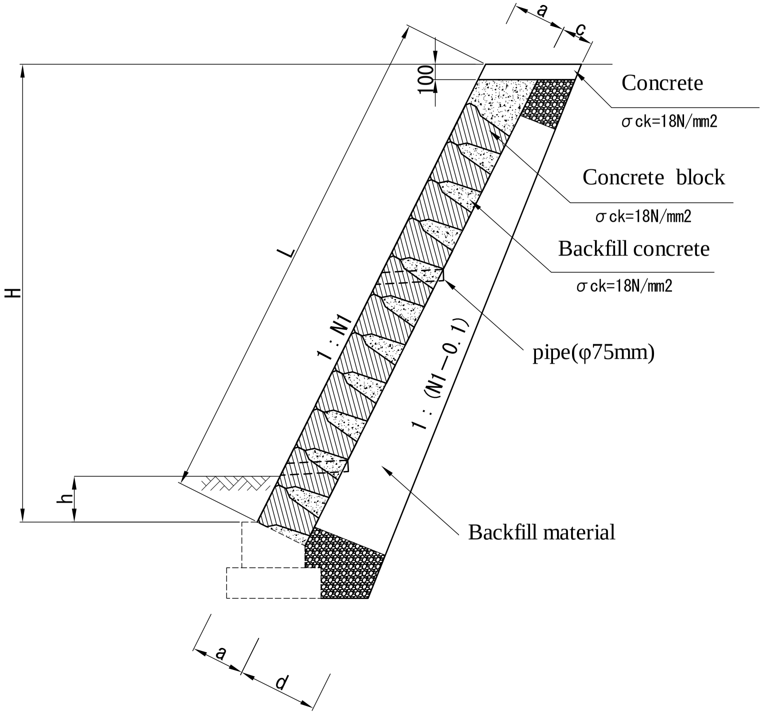
H	L				(mm)							
	N1				U1				U2			
	1:0.3	1:0.4	1:0.5	a	c	d			c	d		
(m)						1:0.3	1:0.4	1:0.5		1:0.3	1:0.4	1:0.5
1.00	1044	1077	1118	350	200	339	335	300	300	439	435	430
1.50	1566	1616	1677	350	200	387	381	374	300	487	481	474
2.00	—	2154	2236	350	200	—	427	419	300	—	527	519
2.50	—	2693	2795	350	200	—	474	454	300	—	574	564
3.00	—	3231	3354	350	200	—	520	509	300	—	620	609
3.50	—	—	3913	350	200	—	—	553	300	—	—	653
4.00	—	—	4473	350	200	—	—	598	300	—	—	698
4.50	—	—	5031	350	200	—	—	643	300	—	—	743
5.00	—	—	5590	350	200	—	—	687	300	—	—	787



(mm)

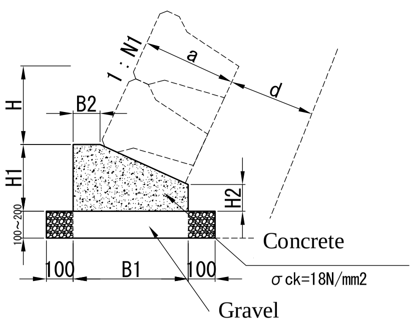
a	B1	B2	H1	H2
350	430	100	250	100

【D-4】 Concrete block(plastered with cement)



(mm)

H	L				(mm)							
	N1				U1				U2			
	1:0.3	1:0.4	1:0.5	a	c	d			c	d		
(m)						1:0.3	1:0.4	1:0.5		1:0.3	1:0.4	1:0.5
1.00	1044	1077	1118	350	200	339	335	300	300	439	435	430
1.50	1566	1616	1677	350	200	387	381	374	300	487	481	474
2.00	—	2154	2236	350	200	—	427	419	300	—	527	519
2.50	—	2693	2795	350	200	—	474	454	300	—	574	564
3.00	—	3231	3354	350	200	—	520	509	300	—	620	609
3.50	—	—	3913	350	200	—	—	553	300	—	—	653
4.00	—	—	4473	350	200	—	—	598	300	—	—	698
4.50	—	—	5031	350	200	—	—	643	300	—	—	743
5.00	—	—	5590	350	200	—	—	687	300	—	—	787



(mm)

a	B1	B2	H1	H2
350	430	100	250	100

3.4 Calculation of Bill of Quantity (BOQ)

The calculation of bill of quantity of Table C and D as well as basis of calculation are elaborated in these chapters.

Construction method where slope ratio is less than 1:1.5 (Table C)

Designation of method		Ref. page
C-1	Sodding	p.32
C-2	Synthetic geotextile sheet	p.33
C-3	Natural rock (not plastered with cement	p.34
C-4	Natural rock (not plastered cement)	p.35
C-5	Stacking wire mesh boxes	p.36
C-6	Laying concrete boxes	p.37

Construction method where slope ratio is greater than 1:1.5 (Table D)

Designation of method		Ref. page
D-1	Natural rock (plastered with cement	p.38
D-2	Multiple-layered wire mesh boxes	p.39
D-3	Stacking wire mesh boxes (not plastered with cement)	p.40
D-4	Stacking wire mesh boxes (plastered with cement)	p.41

(C-1) Sod

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.3	19,100	5,730	
2	General staff		Person	2.7	14,000	37,800	
3	Sod		m^2	100.0	410	41,000	
4	Miscellaneous expenses		%	3.0	84,530	2,536	Formula 1
	Total					87,066	
	Per 1 m^2					871	
					Estimated price	900	(yen/m^2)

Formula 1

Take account of miscellaneous expenses in total labor cost (Item 1, 2) and material cost (Item 3)

(1) + (2) + (3) ……………….(Formula 1)

・Miscellaneous expense ratio does not exceed a maximum of 3%

1) Civil engineer	5,730
2) General staff	37,800
3) Sod	41,000
Total	84,530

(C-2) Synthetic geotextile sheet

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.3	19,100	5,730	
2	General staff		Person	2.7	14,000	37,800	
3	Synthetic geotextile		m^2	100.0	2,000	200,000	
4	Miscellaneous expenses		%	3.0	243,530	7,306	Formula 1
	Total					250,836	
	Per 1 m^2					2,508	
					Estimated price	2,500	(yen/m^2)

Formula 1

Take account of miscellaneous expenses in total labor cost (Item 1, 2) and material cost (Item 3)

(1) + (2) + (3) ……………….(Formula 1)

・Miscellaneous expense ratio does not exceed a maximum of 3%

1) Civil engineer	5,730
2) General staff	37,800
3) Synthetic geotextile	200,000
Total	243,530

(C-3) Natural rock (not plastered with cement)

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.58	19,100	11,078	
2	Expert		Person	0.58	17,300	10,034	
3	General staff		Person	1.15	14,000	16,100	
4	Rock material		m^2	10.0	1,500	15,000	
5	Backfill material	Recycled crushed rock	m^3	2.4	1,200	2,880	Formula 1
6	Filler material	Pieces of rock and concrete	m^3	2.26	4,500	10,170	Formula 2
7	Soil retention membrane	Thickness 10mm	m^2	10.9	510	5,559	Formula 3
8	4-wheel crane driving	Lift 25t	วัน	0.3	38,400	11,520	
9	Backhoe driving	Load bearing 0.8m^3	hr	1.79	9,187	16,445	
10	Miscellaneous expenses		%	1.0	37,212	372	Formula 4
	Total					99,158	
	Per 1 m^2					9,916	
					Estimated price	9,900	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)……………….(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of filler material (m^3) = Design quantity x (1 + K)……………….(Formula 2)

・Standard loss rate K is set at 13%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.13) = 2.26(m^3)

Formula 3

Usage quantity of soil retaining material (m^2) = Design quantity x (1 + K)……………….(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retaining material per 10(m^2) = 10(m^2) x (1 + 0.09) = 10.9(m^2)

Formula 4

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)……………….(Formula 4)

・Miscellaneous expense ratio does not exceed a maximum of 1%

1) Civil engineer		11,078
2) Expert		10,034
3) General staff		16,100
	Total	37,212

(C-4) Natural rock (plastered with cement)

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.83	19,100	15,853	
2	Expert		Person	1.30	17,300	22,490	
3	General staff		Person	1.94	14,000	27,160	
4	Rock material		m^2	10.0	1,500	15,000	
5	Backfill material	Recycled crushed rock	m^3	2.4	1,200	2,880	Formula 1
6	Filler material	Pieces of rock and concrete	m^3	1.120	11,800	13,216	Formula 2
7	Soil retainer membrane	Thickness 10mm	m^2	10.9	1,420	15,478	Formula 3
8	4-wheel crane driving	Lift 25t	Day	0.6	38,400	23,040	
9	Backhoe driving	Load bearing 0.8m^3	hr	2.38	9,187	21,865	
10	Miscellaneous expenses		%	8.0	65,503	5,240	Formula 4
	Total					162,222	
	Per 1 m^2					16,222	
					Estimated price	16,200	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)……………….(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of concrete filler (m^3) = [(D×10m2) - (VxN)]………………….(Formula 2)

・Suppose D is rock diameter which is equal to 0.5m.

Volume V=(pxD^3)/2, Area A'=(√3xD^2)/2, Basic quantity N=10/A'

Design quantity per 10(m^2) is equal to [0.5 x 10 - 0.06 x 46]/2 = 1.12(m^3)

Formula 3

Usage quantity of waterproof membrane (m^2) = Design quantity x (1 + K)………(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retention membrane per 10(m2$^)$ = 10(m2$^)$x (1 + 0.09) = 10.9(m2$^)$

Formula 4

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

・Miscellaneous expense ratio does not exceed a maximum of 1%

1) Civil engineer		15,853
2) Expert		22,490
3) General staff		27,160
	Total	65,503

(C-5) Wire mesh box

Calculated unit price per 100 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.8	19,100	15,280	
2	Expert		Person	1.2	17,300	20,760	
3	General staff		Person	9.9	14,000	138,600	
4	Wire mesh box	Thickness	m^2	100.0	5,690	569,000	
5	Pieces of rock and concrete		m^3	48.6	4,500	218,700	Formula 1
6	Soil retention membrane	Thickness	m^2	107.0	510	54,570	Formula 2
7	Backhoe driving	Load bearing 0.8m^3	hr	8.2	8,845	72,529	
8	Miscellaneous expenses		%	4.0	247,169	9,887	Formula 3
	Total					1,099,326	
	Per 1 m^2					10,993	
					Estimated price	11,000	(yen/m^2)

Formula 1

Usage quantity of mid-section rockfill material (m^3) = Design quantity x (1 + K)……………..(Formu

・Design quantity is set at 90% of wire mesh box volume

Design quantity per 100(m^2) is equal to 100(m^2)x 0.5(m) x 0.9 = 45(m^3)

・Standard loss rate K is set at 8%

Usage quantity of mid-section rockfill material per 100(m^2) = 45(m^3) x (1 + 0.08) = 48.6(m^3)

Formula 2

Usage quantity of soil retaining material (m^2) = Design quantity x (1 + K)…….(Formula 2)

・Standard loss rate K is set at 7%

Usage quantity of soil retaining material per 100(m^2) = 100(m^2) x (1 + 0.07) = 107(m^2)

Formula 3

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3) and equipment rental cost (Item 7)

(1) + (2) + (3)………………..(Formula 3)

・Miscellaneous expense ratio does not exceed a maximum of 4%

1) Civil engineer	15,280
2) Expert	20,760
3) General staff	138,600
7) Backhoe driving	72,529
Total	247,169

(C-6) Laying concrete block

Calculated unit price per 10 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.1	19,100	1,910	
2	Bricklayer		Person	0.2	19,200	3,840	
3	Special staff		Person	0.2	17,300	3,460	
4	General staff		Person	0.7	14,000	9,800	
5	Concrete block		m^2	10.0	10,000	100,000	
6	Soil retaining material installer	Thickness 10mm	m^2	11.2	510	5,712	Formula 1
7	4-wheel crane driving	Lift 25t	Day	0.2	38,400	7,680	
8	Miscellaneous expenses		%	4.0	26,690	1,068	Formula 2
	Total					133,470	
	Per 1 m^2					13,347	
					Estimated price	13,300	(yen/m^2)

Formula 1

Usage quantity of soil retaining material (m^2) = Design quantity x (1 + K)………(Formula 2)

・Standard loss rate K is set at 12%

Usage quantity of soil retaining material per 10(m^2) = 10(m^2) x (1 + 0.12) = 11.2(m^2)

Formula 2

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3) and equipment rental cost (Item 7)

(1) + (2) + (3) + (4) + (7)………………..(Formula 3)

・Miscellaneous expense ratio does not exceed a maximum of 4%

1) Civil engineer	1,910
2) Bricklayer	3,840
3) Special staff	3,460
4) General staff	9,800
7) 4-wheel crane driving	7,680
Total	26,690

(D-1) Natural rock (plastered with cement)

Calculated unit price per 10 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.83	19,100	15,853	
2	Expert		Person	1.30	17,300	22,490	
3	General staff		Person	1.94	14,000	27,160	
4	Rock material		m^2	10.0	1,500	15,000	
5	Backfill material	Recycled crushed rock	m^3	2.4	1,200	2,880	Formula 1
6	Concrete	High pressure	m^3	1.120	11,800	13,216	Formula 2
7	Waterproof material	Thickness 10mm	m^2	10.9	1,420	15,478	Formula 3
8	4-wheel crane driving	Lift 25t	Day	0.6	38,400	23,040	
9	Backhoe driving	Load bearing 0.8m^3	hr	2.38	9,187	21,865	
10	Miscellaneous expenses		%	8.0	65,503	5,240	Formula 4
	Total					162,222	
	Per 1 m^2					16,222	
					Estimated price	16,200	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)……………..(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of concrete filler (m^3) = [(D×10m2) - (VxN)]………………….(Formula 2)

・Suppose D is rock diameter which is equal to 0.5m.

Volume V=(pxD^3)/2, Area A'=(√3xD^2)/2, Basic quantity N=10/A'

Design quantity per 10(m^2) is equal to [0.5 x 10 - 0.06 x 46]/2 = 1.12(m^3)

Formula 3

Usage quantity of waterproof membrane (m^2) = Design quantity x (1 + K)……….(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retention membrane per 10(m2) = 10(m2)x (1 + 0.09) = 10.9(m2)

Formula 1

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

・Miscellaneous expense ratio does exceed a maximum of 1%

1) Civil engineer		15,853
2) Expert		22,490
3) General staff		27,160
	Total	65,503

(D-2) Multi-layered wire mesh boxes

Calculated unit price per 350 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	General staff		Person	57.0	14,000	798,000	
2	Wire mesh box	Multi layers	m^2	350.0	5,690	1,991,500	
3	Pieces of rock and concrete		m^3	332.0	4,500	1,494,000	
4	Soil retention membrane	Thickness 10mm	m^2	600.0	510	306,000	
5	Backhoe driving	Load bearing 0.8m^3	hr	16.0	8,845	141,520	
	Total					4,731,020	
	Per 1 m^2					13,517	
					Estimated price	13,500	(yen/m^2)

(D-3) Concrete block (not plastered with cement)

Calculated unit price per 10 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		คน	0.58	19,100	11,078	
2	Expert		คน	0.58	17,300	10,034	
3	General staff		คน	1.15	14,000	16,100	
4	Concrete block		m^2	10.0	7,000	70,000	
5	Backfill material	Recycled crushed rock	m^3	2.40	1,200	2,880	Formula 1
6	Filler material	Pieces of rock and concrete	m^3	2.26	4,500	10,170	Formula 2
7	Soil retaining material	Thickness 10mm	m^2	10.9	510	5,559	Formula 3
8	4-wheel crane driving	Lift 25t	วัน	0.3	38,400	11,520	
9	Backhoe driving	Load bearing 0.8m^3	hr	1.79	9,187	16,445	
10	Miscellaneous expenses		%	1.0	37,212	372	Formula 4
	Total					154,158	
	Per 1m2					15,416	
	Per 1m2				Estimated price	15,400	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)…………(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of filler material (m^3) = Design quantity x (1 + K)……………….(Formula 2)

・Standard loss rate K is set at 13%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.13) = 2.26(m^3)

Formula 3

Usage quantity of soil retaining material (m^2) = Design quantity x (1 + K)……….(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retaining material per 10(m^2) = 10(m^2) x (1 + 0.09) = 10.9(m^2)

Formula 4

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

・Miscellaneous expense ratio does exceed a maximum of 1%

1) Civil engineer		11,078
2) Expert		10,034
3) General staff		16,100
	Total	37,212

(D-4) Concrete block (not plastered with cement)

Calculated unit price per 10 m^2

	Description	Standard	Unit	Quantity	Unit price	Amount	Note
1	Civil engineer		Person	0.83	19,100	15,853	
2	Expert		Person	1.30	17,300	22,490	
3	General staff		Person	1.94	14,000	27,160	
4	Concrete block		m^2	10.0	7,000	70,000	
5	Backfill material	Recycled crushed rock	m^3	2.4	1,200	2,880	Formula 1
6	Filler material	Pieces of rock and concrete	m^3	1.120	11,800	13,216	Formula 2
7	Soil retention membrane	Thickness 10mm	m^2	10.9	1,420	15,478	Formula 3
8	4-wheel crane driving	Lift 25t	Day	0.6	38,400	23,040	
9	Backhoe driving	Load bearing 0.8m^3	hr	2.38	9,187	21,865	
10	Miscellaneous expenses		%	8.0	65,503	5,240	Formula 4
	Total					217,222	
	Per 1m2					21,722	
					Estimated price	21,700	(yen/m^2)

Formula 1

Usage quantity of backfill material (m^3) = Design quantity x (1 + K)…………(Formula 1)

・Standard loss rate K is set at 20%

Design quantity per 10(m^2) is equal to 10(m^2) x thickness 0.2(m) x (1+0.2) = 2.4(m^3)

Formula 2

Usage quantity of concrete filler (m^3) = [(D×10m2) - (VxN)]………………….(Formula 2)

・Suppose D is rock diameter equal to 0.5m.

Volume V=(pxD^3)/2, Area A'=(√3xD^2)/2, Basic quantity N=10/A'

Design quantity per 10(m^2) is equal to [0.5 x 10 - 0.06 x 46]/2 = 1.12(m^3)

Formula 3

Usage quantity of waterproof membrane (m^2) = Design quantity x (1 + K)……….(Formula 3)

・Standard loss rate K is set at 9%

Usage quantity of soil retention membrane per 10(m2) = 10(m2) x (1 + 0.09) = 10.9(m2)

Formula 4

Take account of miscellaneous expenses in total labor cost (Item 1, 2, 3)

(1) + (2) + (3)………………..(Formula 4)

・Miscellaneous expense ratio does exceed a maximum of 1%

1) Civil engineer		15,853
2) Expert		22,490
3) General staff		27,160
	Total	65,503