Directorate General of Water Resources,
Ministry of Public Works
Republic of Indonesia

THE PROJECT FOR CAPACITY DEVELOPMENT OF JAKARTA COMPREHENSIVE FLOOD MANAGEMENT IN INDONESIA

TECHNICAL COOPERATION REPORT

MEASURE AND OPERATION MANUAL FOR RUNOFF CONTROL FACILITY

OCTOBER, 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

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The Project for Capacity Development of
Jakarta Comprehensive Flood Management
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Technical Cooperation Report
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CHAPTER 1 INTRODUCTION

1.1 Runoff Control Measures for Comprehensive Flood Management

Ciliwung River running through the central area in Jakarta Special Province (DKI Jakarta) has caused a large scale flood disaster every 5 years, resulting in the serious impacts to the capital in Indonesia. On the other hand, in Ciliwung River Basin, due to the rapid economic growth, the urbanization area is increasing causing the reduction of retention and retarding functions in the basin, and land subsidence is induced by the excess use of groundwater. If the urbanization and excess groundwater use continue in the current speed, it is assumed that the peak discharge in the river course will rise in the heavy rainfall, and inundation area will extend.

In order to reduce the flood disaster risks, it is necessary to implement measures for comprehensive flood management shown below in coordination and collaboration among the related government organizations. Runoff control measures can be carried out by installing runoff control facilities for reducing the runoff from developed areas.

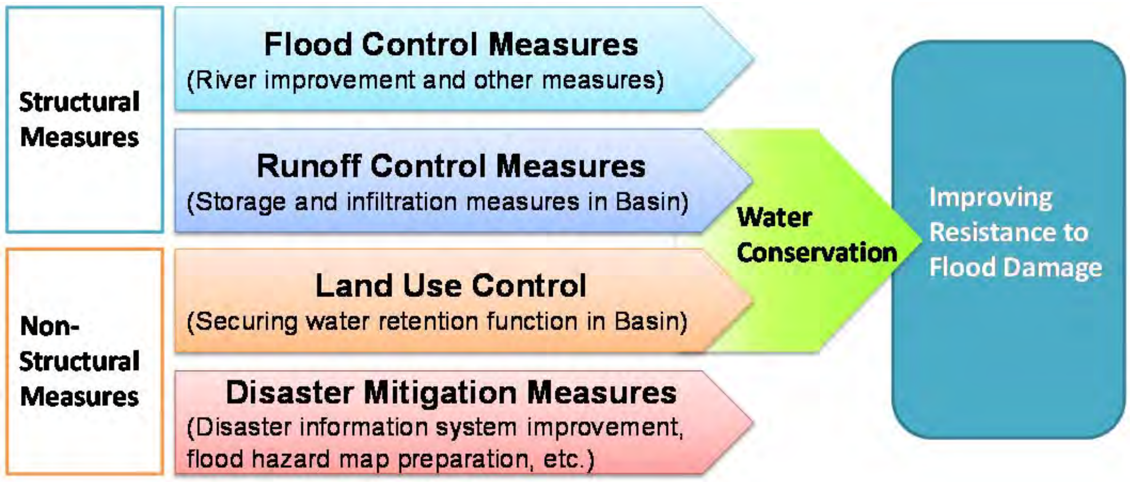


Figure 1.1-1 Conceptual Figure of CFMP

1.2 Purpose of this Manual

This manual describes concept, methodology, effect evaluation and maintenance of several runoff control measures, namely plastic rainwater storage and infiltration facility, and *situ* improvement work, in order to promote the implementation of the runoff control measures.

CHAPTER 2 RUNOFF CONTROL MEASURES

2.1 Outline of Runoff Control Facility

Even though the various runoff control facilities exist, those can be clarified into 2 types: storage facility and infiltration facility.

The storage facility is the facility to control the runoff discharge by storing the rainwater temporarily and release the stored water to the downstream gradually. The infiltration facility functions to recharge the rainwater into the ground. Besides, there is a storage facility which also can promote rainwater infiltration. This kind of facility is called Rainwater Storage and Infiltration Facility (RSIF).

Storage facility is also divided into the following two categories.

- Off-site storage facility which collects and stores rainwater through channel or river
- On-site storage facility which stores rainwater directly consisting storage facility and infiltration facility

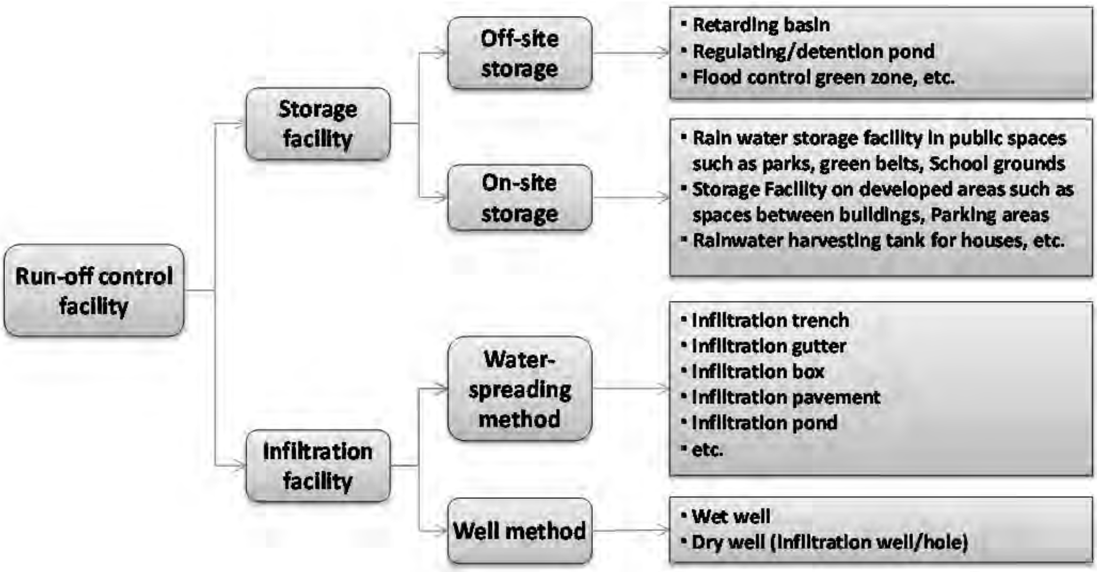


Figure 2.1-1 Runoff Control Facility

The examples of major runoff control facilities are shown below.

Utilized as Tennis Court during Normal Time

Storage Facility in Jakarta

Figure 2.1-2 Examples of Off-site Storage Facility

Figure 2.1-3 Examples of On-site Storage Facility using Plastic Material

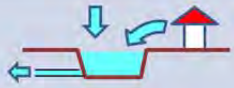
Infiltration box and Trench
(Example in Japan)

Infiltration well (Example in Bogor)

Figure 2.1-4 Examples of Infiltration Facility

Characteristics of storage facility and infiltration facility are summarized as follows.

Table 2.1-1 Characteristics of Infiltration Facility and Storage Facility

Item	Infiltration Facility	Storage Facility
Schematic Diagram		
1. Major Function	• To reduce the outflow of rainwater by accelerating the infiltration of rainwater to underground. • To contribute to recharge of groundwater	• To reduce the outflow of rainwater by storing the rainfall temporarily.
2. Key Consideration for Planning	The following places needs to be avoided . • A place where water is difficult to infiltrate • A steep terrain where ground may become loose and cause landslide	Except for small facility such as a rainwater harvesting tank, a downstream channel has sufficient flow capacity .
3. Ceiling on Performance	Even if the facility is filled up, the amount of infiltration can be taken into account as runoff control effect.	The facility is effective until it is filled up.
4. Type of Facilities	• Infiltration Well (*Sumur Resapan*) • Infiltration Pond (*Kolam Resapan, Situ*) • Infiltration Hole (*Biopori*) • Rainwater Storage Infiltration Facility proposed by JICA, etc.	[Off-site] • Regulating Pond (Improved *Situ*) • Retarding Basin, etc. [On-site] • Rainwater Harvesting Tank • Storage area at schoolyards and parks (in Japan), etc.
Evaluation Policy of Runoff Control Function	Even if the facility is filled up, the amount of infiltration can be taken into account as runoff control effect. Therefore, runoff control function of the infiltration facility shall be taken into account in the CFMP for the Ciliwung River	At the time of an infrequently-occurred large scale rainfall, the storage facilities may be filled up before the peak inflow. Therefore, basically runoff control function of the storage facilities is taken into account only in case of a small-medium scale rainfall with 1 ~ 10-year return period.

2.2 Target for Installation of Storage Facility and Infiltration Facility per Unit Area

In order to plan the installation of storage facility and infiltration facility in a certain catchment area, the total storage volume shall be targeted as 500 m^3/ha.

According to the Japanese standard, the targeted volume for the installation of storage facility and infiltration facility in a developed catchment area is as follows. Those targeted volume is set from the viewpoint of the realistic volume in the developed land.

Table 2.2-1 Japanese Standard of Targeted Volume for Storage/Infiltration Facility

Catchment Area (ha)	0.05	0.10	0.30	0.50	1.00	>1.0
River Name						
Draft Guideline by *Cipta Karya* [1]	1,200 m^3/ha					
Nakagawa&Ayase River	No Regulation	500 m^3/ha				950 m^3/ha
Shingashi River	No Regulation	500 m^3/ha				950 m^3/ha
Sakai River (Kanagawa)	No Regulation		Depend on Regulation for each Municipal/City			
Turumi River	No Regulation		600 m^3/ha			
Shinkawa River	600 m^3/ha					
Sakai River (Aichi)	600 m^3/ha					
Yamato River	No Regulation				300 m^3/ha	585 m^3/ha
Ina River	No Regulation					600 m^3/ha
Neya River	No Regulation		300 m^3/ha	400 m^3/ha		600 m^3/ha

Source:
1) *Pedoman Teknis Pengelolaan Genangan Air Hujan pada Lingkungunan Bangunan Gedung* (Draft), Directorate General of Human Settlements, 2010
2) Ministry of Land Infrastructure, Transportation and Tourism, Japan

For the installation planning of infiltration well (*sumur resapan*), the following regulation and standards can be referred.

- *PerGub No. 20/2013 Tentang Sumur Resapan*
- *SNI* 03-2453-2002: *Tata Cara Perencanaan Sumur Resapan Air Hujan untuk Lahan Pekarangan* (Planning of Rainwater Infiltration Well in a Housing Site)
- *SNI* 06-2459-2002: *Spesifikasi Sumur Resapan Air Hujan untuk Lahan Pekarangan* (Specification of Rainwater Infiltration Well in a Housing Site)

<u>Note : Result of Case Study</u>

Regarding public facilities such as school, public office and parks, available land for rainwater storage and infiltration facility in every facility is different due to the land use. In order to identify practical volume of storage and infiltration facility in those public facilities, JCFM Project carried out case study. The followings are the result of practical storage volume.

- School ground : 140 m^3/ha
- Public office site : 100 m^3/ha
- Park : 150 m^3/ha

Table 2.2-2 Estimation of Unit Amount (School: Case Study in South Jakarta)

Name of School	Area (m^2) (a)	Infiltration Well (Number)	Volume for Infiltration Well (m^3) (b)	Unit Amount (m^3/ha) (1)= (b)/(a) x 1,000
SMK NGGERI 30	5,200	7	42	81
SMPN 11	4,800	4	24	50
SMPN 2 SSN	4,000	5	30	75
SMPN 28	4,000	7	42	105
SDN Bambu Apus	5,450	10	60	110
SDN Kp. Tengah	8,480	42	252	297
SDN Percontohan Lubang Buaya	3,830	11	66	172
Average				140

Source: JCFM Project

Figure 2.2-1 Estimation of Unit Amount (Public Building: Case Study in Bogor Regency)

Table 2.2-3 Estimation of Unit Amount (Park: Case Study in South Jakarta)

Name of Park	Area (m^2) (a)	Infiltration Well (Number)	Volume for Infiltration Well (m^3) (b)	Unit Amount (m^3/ha) (1)= (b)/(a) x 1,000
Taman Eks SPBU Jl. Mataram	1,929	4	24	124
Taman Eks SPBU Jl. Mataram	1,285	4	24	187
Taman Rumah Dinas Jabatan Wagub	797	2	12	151
Average				150

Source: JCFM Project

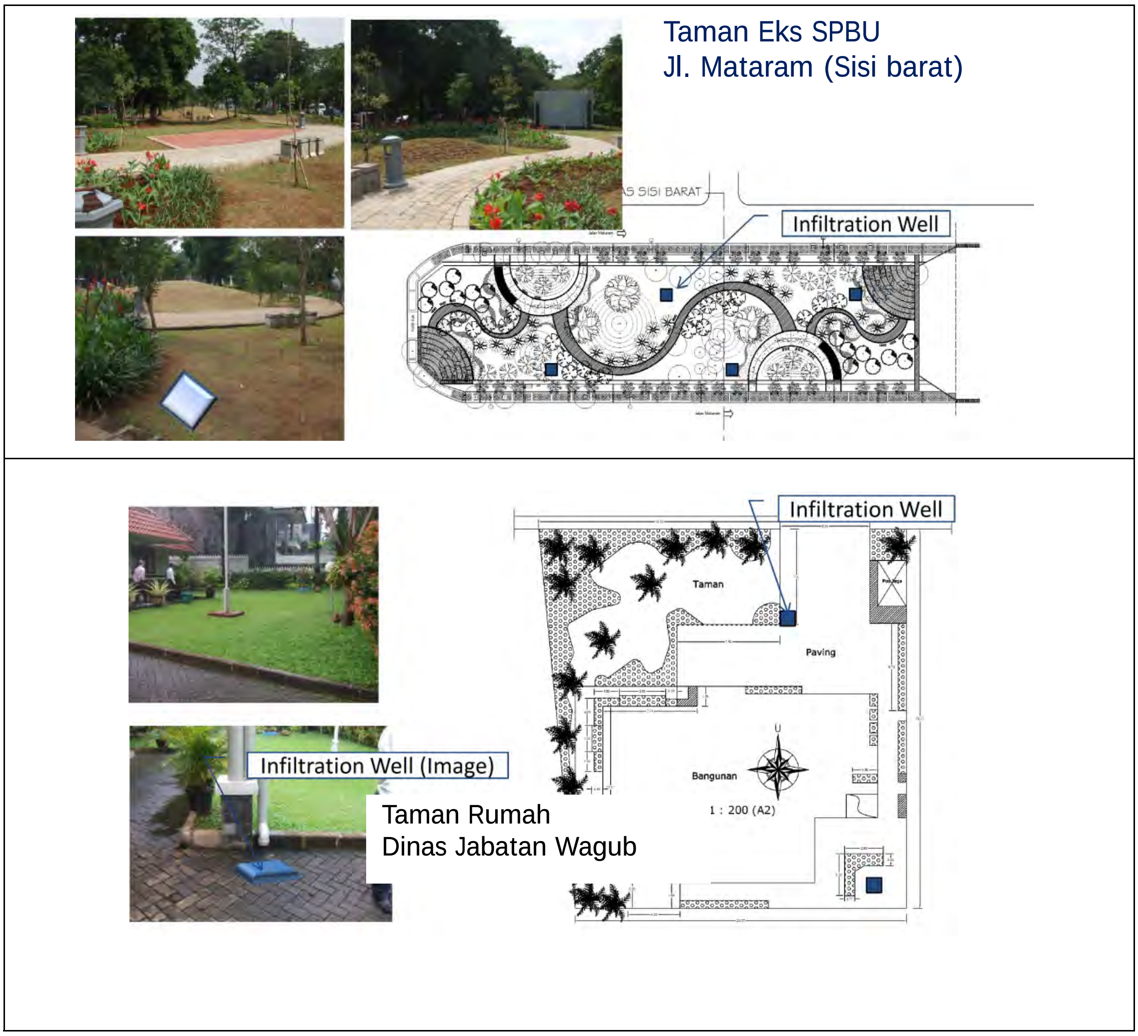


Figure 2.2-2 Layout of Infiltration Facility in Park (Case Study)

2.3 Flood Control Effect by Runoff Control Facility

When the total 2,878,000 m^3/s of rainwater storage and infiltration facilities are installed in the Ciliwung River Basin, flood control effect by those facilities at Manggarai Water Gate can be calculated using the following manner.

(1) Runoff Calculation

a) It is assumed that the most of the rainwater storage and infiltration facilities to be installed in Ciliwung River Basin is infiltration well (*Sumur Resapan*). In addition, those wells are collectively simplified as one large rainwater infiltration facility which equally infiltrates the rainwater from the ground in the whole basin.

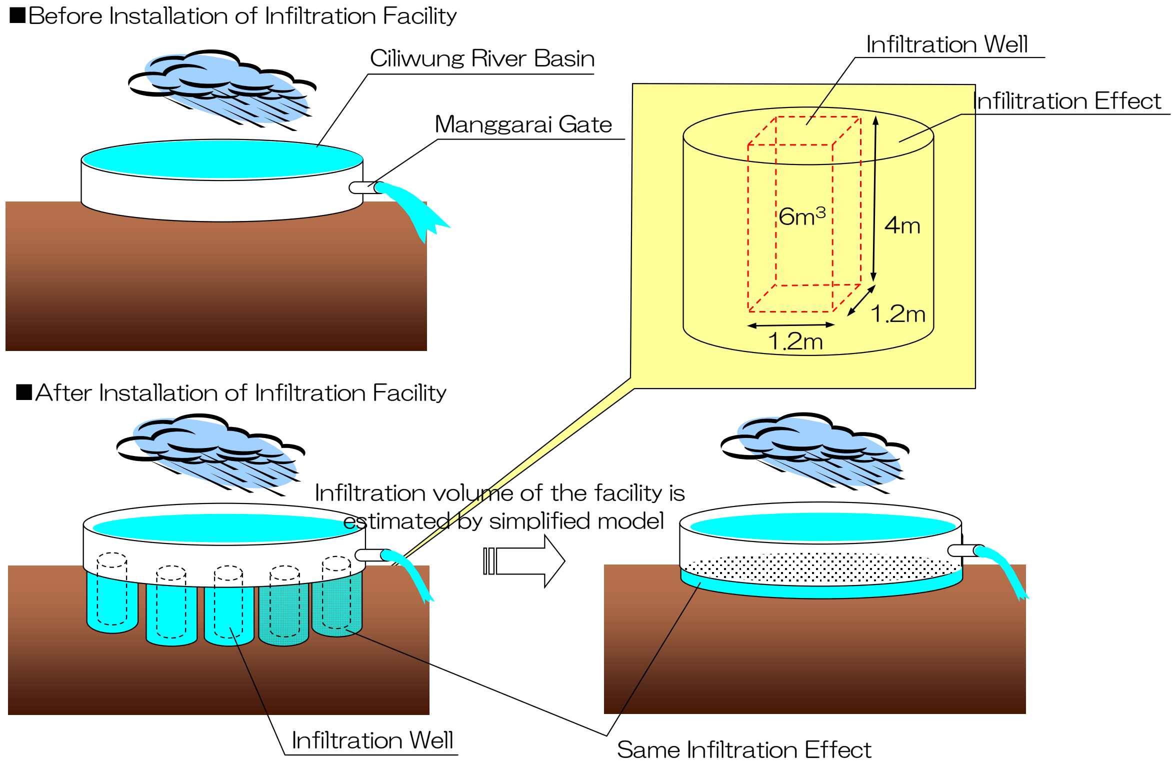


Figure 2.3-1 Conceptual Diagram for Evaluation of Runoff Control Effect by Several Infiltration Wells in the Basin

b) 24-hour infiltration volume by the above simplified facility (V_{p24}) is estimated based on the rainfall amount to be infiltrated from the ground (R_p) and basin area (A) as follows.

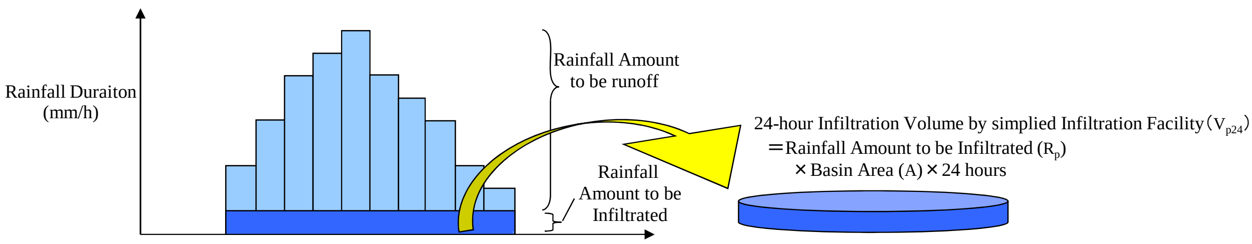


Figure 2.3-2 Estimation of 24-Hour Infiltration Volume by Simplified Rainwater Infiltration Facility

c) Several cases on rainfall amount to be infiltrated are assumed, and the runoff calculation is conducted in each case. Moreover, the relations among the following coefficients are examined: rainfall amount to be infiltrated (R_p), 24-hour infiltration volume by simplified infiltration facility (V_{p24}), runoff control volume at Manggarai Gate (Q_r), and controlled volume at Manggarai Gate (V_r). The controlled volume at Manggarai Gate is equivalent to the 24-hour discharge volume including the occurrence time of peak discharge.

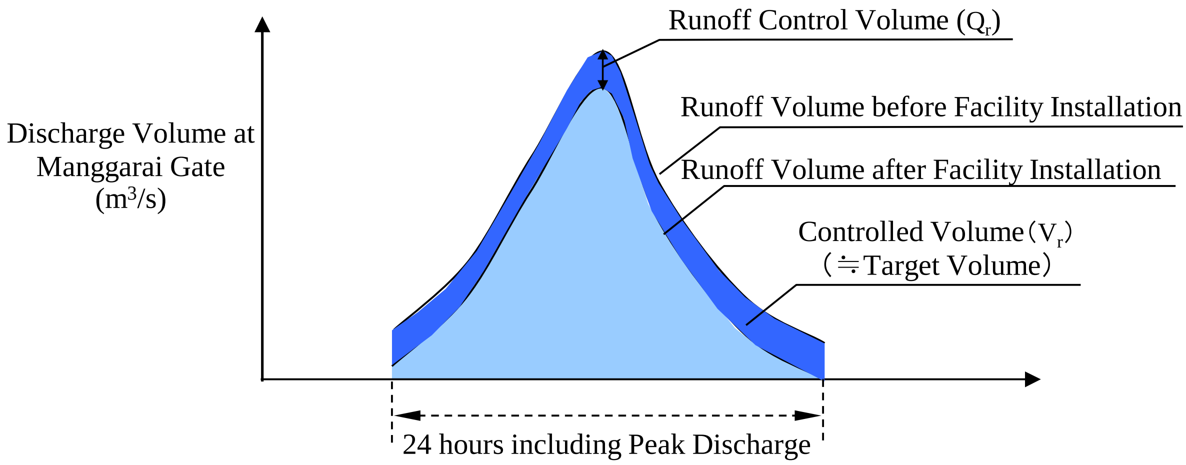


Figure 2.3-3 Conceptual Diagram of Runoff Control Effect by Infiltration Well

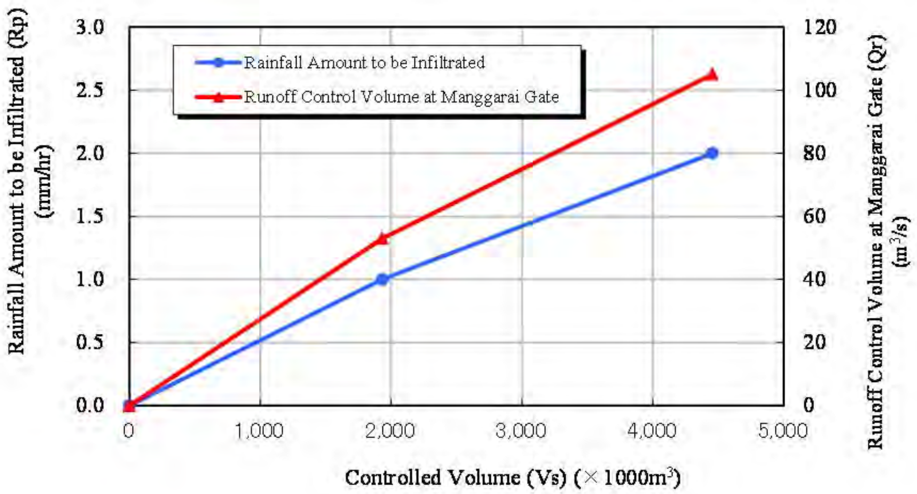


Figure 2.3-4 Relation between Runoff Control Volume at Manggarai Gate Point and Rainfall Amount to be Infiltrated

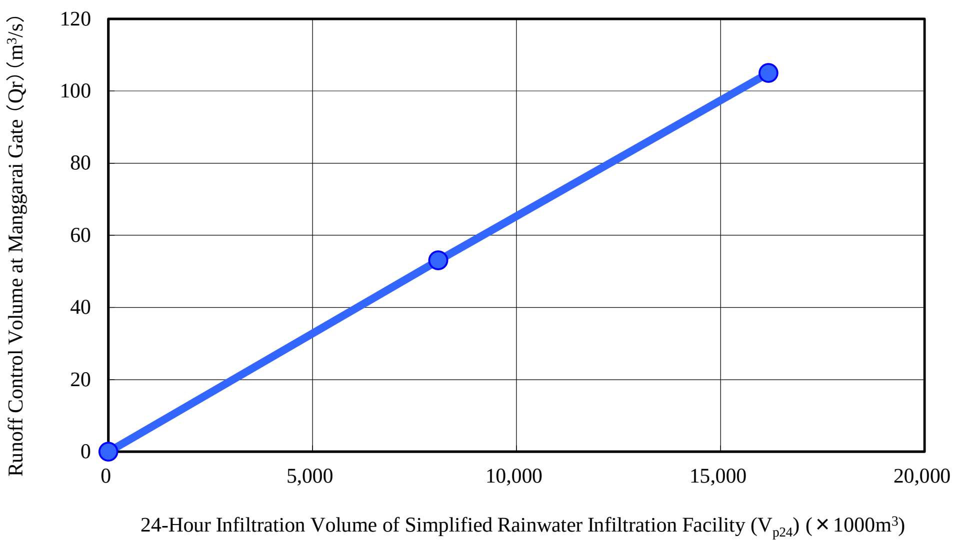


Figure 2.3-5 Infiltration Volume by Simplified Facility and Runoff Control Volume at Manggarai Gate Point

(2) Estimation of Runoff Control Volume

a) In case that the target volume of rainwater storage and infiltration facilities to be installed in Ciliwung River Basin as set previously (2,878,000 m^3) is filled by the rainwater, it is considered the total controlled volume at Manggarai Gate (V_r) will be equivalent to this volume. Therefore, based on Figure 2.3-4 and calculation, the runoff control volume at Manggarai Gate (Q_r) is estimated as "Q_r = 72 m^3/s", which is equivalent to 2,878,000 m^3 of runoff control volume (see Figure 2.3-5).

(3) Confirmation of Infiltrated Volume by Rainwater Storage and Infiltration Facility

a) With assumption that all the facilities are infiltration well, based on the average size and infiltration volume, the total infiltration volume from inside of infiltration well to surrounding underground areas is estimated by the following formula.

Total Infiltration Volume (V_f) = 2,878,000 m^3 (target volume) / 6 m^3 (volume of each infiltration well)
x 1.48 m^3 (permeability of each infiltration well*) x 24 hours

* permeability of each infiltration well is surveyed by JCFM project.

b) It is confirmed that the estimated total infiltration volume (V_f) is larger than 24-hour infiltration volume by simplified rainwater infiltration facility (V_{p24}) which is equivalent to runoff control volume at Manggarai Gate (Q_r) estimated by Figure 2.3-5 (see Table 2.3-1).

Table 2.3-1 Flood Control Effect by Runoff Control Facility

	Target Volume (×1,000m3)	Rainfall Amount to be Infiltrated (Rp) (mm/h)	Runoff Control Volume at Manggarai Gate (Qr) (m3/s)	Required Volume for Infiltrated Rainfall(Rp) (Vp24) (×1000m3)	Total Infiltration Volume (V_f) (×1,000m3)	Total Infiltration Volume (V_{p24}) > Required Infiltration Volume (V_f)
Rainwater Infiltration/Storage Facility	2,878	1.4	72	11,326	17,038	O.K.

CHAPTER 3 PLASTIC RAINWATER STORAGE AND INFILTRATION FACILITY

3.1 General

JCFM Project constructed a Rainwater Storage and Infiltration Facility (RSIF) by means of plastic materials in Ciliwung-Cisadane River Basin Management Main Office.

In this chapter, concept, design, construction, effect evaluation and maintenance for RSIF is discussed.

3.1.1 Purpose

This manual is to describe technological matters relating to design, construction and maintenance of the underground rainwater storage and infiltration facility made of plastic components, installed to control rainwater effluent.

(Commentary)
The underground rainwater storage and infiltration facility made of plastic components (hereinafter referred to as “the Facility”) represents in this manual the facility composed of reservoir including storage structure and sheets, and auxiliary facilities.

The number of the Facilities has been significantly increasing these days, as one of flood control techniques. The facility scale ranges from small sizes for detached houses to large sizes for extensive development projects, giving great impacts upon the surroundings.

However, with regard to the plastic storage structure of the Facility, no reliable method has been established for assessing its strength and durability, etc. It should be noted that accidents such as cave-in occurred because of excessive loads and other reasons.

Under these circumstances, systematic development of technological matters is desired for ensuring safety and security of every person concerned with the Facility including designers, constructors and users of the land above the Facility.

This manual describes technological matters relating to design, construction and maintenance required for installation of the Facility.

3.1.2 Applicability

Table 3.1-1 shows the Facilities in the applicable scope of this manual. Figure 3.1-1 illustrates the position of each dimension of the Facility.

Table 3.1-1 Applicable Scope

	Facilities and installation conditions	Installation places
In the applicable scope	-Plastic components are assembled on site and embedded -Overburden: 0.5 to 2 m -Reservoir height: max. 4 m -Withstands T-25 load (10kN/m^2) -With long durability -Ensuring normal function under level 2 seismic motion	-Schoolyard -Park -Parking lot -Green zone -Residential land -Walkway
Out of the applicable scope	-Traps, perforated pipe trenches described in the manual for sewage rainwater infiltration technology*1 -Precast concrete storage facilities	-Roadway -Liquefied land -Steep slope -Where bottom elevation is lower than groundwater level

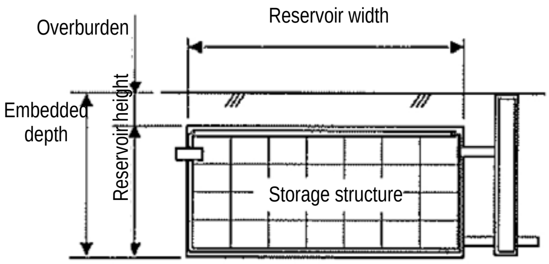


Figure 3.1-1 Position of Each Dimension of the Facility

3.1.3 Applicable Standards

Matters not described in this manual shall conform to the design guidelines, etc. published by relevant organizations.

(Commentary)
The following regulation, standards and manuals can be used.

- *SNI* 03-2453-2002: *Tata Cara Perencanaan Sumur Resapan Air Hujan untuk Lahan Pekarangan* (Planning of Rainwater Infiltration Well in a Housing Site)
- *SNI* 06-2459-2002: *Spesifikasi Sumur Resapan Air Hujan untuk Lahan Pekarangan* (Specification of Rainwater Infiltration Well in a Housing Site)
- *Konsep Petunjuk Teknis Sarana Prasarana Peresapan (Infiltrasi) Air Hujan* (Draft), Prepared by JICA and *Direktorat Bina PSDA* (Technical Concept on Rainwater Infiltration Facilities)
- *Konsep Pengelolaan Air Hujan di halaman Bangunan/Gedung* (Draft), prepared by *Direktorat Jenderal Cipta Karya* (Manual of Rainwater Management in the Courtyards)
- *PerGub No. 20/2013 Tentang Sumur Resapan*

3.1.4 Definition of Terms

For the purpose of this manual, the terms listed below are defined as follows. The terms not listed shall be interpreted according to the "Terminology for Sewage Works, 2000" (published by Japan Sewage Works Agency).

(1) Storage and infiltration facility

Facility composed of reservoir, auxiliary facilities and foundation.

(2) Reservoir

Reservoir composed of storage structure and sheets enveloping the storage structure. Reservoir is a generic term for storing tank, infiltrating tank and tank with both storing and infiltrating functions. Tank with infiltrating function is called infiltration tank or storing infiltration tank in some cases.

(3) Storage structure

Structure forming a required storage space constructed with plastic components.

(4) Components

Plastic members forming the storage structure, made by injection molding, etc.

(5) Auxiliary facilities

A generic term for influent facility, maintenance facility and drainage facility.

(6) Net storage ratio

The ratio of net storage volume of reservoir to its apparent volume. The apparent volume represents the volume calculated from the outer dimensions. The net storage volume refers to the net volume obtained by subtracting the net volume of the storage structure itself and inspection holes, etc. from the apparent volume of the reservoir.

(7) Reservoir height

Height from the bottom to the top of the reservoir.

(8) Reservoir width

Taking the depth as z direction, width refers to length in orthogonal x and y directions.

(9) Embedding depth

Distance from the bottom of the underground reservoir to the surface.

(10) Overburden

Overburden thickness from the top of the underground reservoir to the surface.

(11) Validation items

Requirement items to be satisfied for ensuring safety of the storage structure.

(12) Confirmation items

Requirement items to be preferably satisfied for ensuring further safety of the storage structure.

(13) Hypothetical proportional limit stress

Proportional limit stress refers to the maximum stress reached as long as stress increases in proportion to displacement. When it is difficult to determine the proportional limit stress, hypothetical proportional limit stress is used, which is obtained by a simplified method such as multiplying the maximum stress by a factor.

(14) Material factor

Safety factor in relation to variance, etc. of material.

(15) FEM Analysis

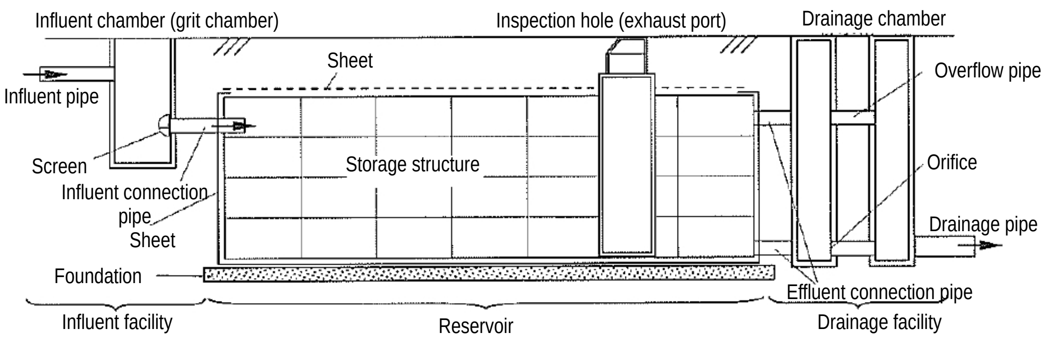
Analysis by means of the finite element method. In this manual, this term mainly refers to the analysis in which the storage structure is modeled by element discretization, to calculate deformations and stresses under applied loads.

3.2 Overview of the Facility

3.2.1 Composition of the Facility

The Facility is composed of the following.
(1) Storage structure
(2) Sheet
(3) Auxiliary facilities
(4) Foundation

(Commentary)
The Facility is composed of reservoir constituted of storage structure and sheet, auxiliary facilities and foundation. The designation of each part is shown in Figure 3.2-1.



*The drainage chamber is installed separately from the reservoir in some cases.

Figure 3.2-1 Name of Each Part of the Facility

(1) Storage structure
Structure forming a required storing space constructed with plastic components. When this structure is provided with storing function, an inspection hole, etc. may be installed.
(2) Sheet
Generic term for water impermeable sheet, water permeable sheet and protection sheet, or combination of these sheets.
(3) Auxiliary facilities
Generic term for influent facility composed of influent chamber (grit chamber) and influent connection pipe, etc. maintenance facility including inspection hole, etc. and drainage facility

composed of drainage chamber, effluent connection pipe, overflow pipe, etc.
(4) Foundation
Base for transferring the load of the reservoir and superimposed load and stored water to the ground.

3.2.2 Types of the Facility

The facility is classified into two types by the kind of sheet used.
(1) Storage facility
(2) Infiltration facility

(Commentary)
The Facility is classified into two types by the kind of sheet used. There is also a storage-infiltration type combining storage and infiltration functions.

(1) Storage facility
Storage facility is composed of reservoir and auxiliary facilities. To ensure the storing function, water impermeable sheet is placed over the outer surface of storage structure and surrounding ground.

Rainwater flows into the storage facility and is once retained there, to be discharged outside through the effluent connection pipe. By adjusting the height of discharge pipe and orifice, it is possible to use rainwater kept in the reservoir. Fig. 3.2-2 is the schematic diagram of the storage facility.

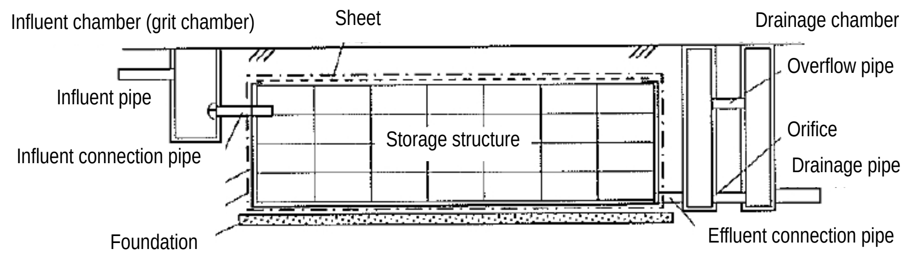


Figure 3.2-2 Outline Drawings Storage Facility

(2) Infiltration facility
The infiltration facility is composed of reservoir with infiltration function and auxiliary facilities. To ensure the infiltration function, water permeable sheet is placed over the outer surface of storage structure and surrounding ground.

Rainwater that flows into the infiltration facility penetrates to the outside of the reservoir through the water permeable sheet. By installing the effluent connection pipe at a higher position of the reservoir and increasing the stored water depth, it is possible to enhance the storage and infiltration functions. Fig. 3.2-3 is the schematic diagram of the facility.

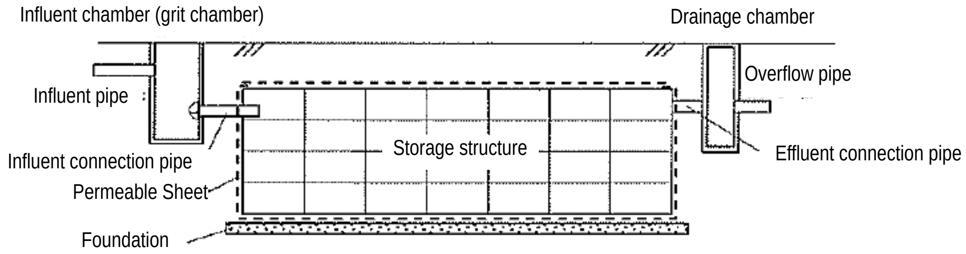


Figure 3.2-3 Outline Drawings Infiltration facility

3.3 Design

3.3.1 Concept of Design

(1) Design Procedures

The Facility should be designed by grasping the properties of the ground of construction site, rainwater flow rate, etc., and confirming the performance of the storage structure, and studying the sheet, foundation and auxiliary facilities, etc., and correctly identifying the items to be noted.

(Commentary)
The procedures for design of the Facility are shown in Figure 3.3-1.

The description in this Chapter is composed of design flow in sections form 3.3.2 to 3.3.6, and flow of performance validation and confirmation of the storage structure constituting the reservoir. In design of the reservoir, the performance of the storage structure is validated and confirmed on the basis of the description in section 3.3.7. The items to be studied include validation items to be satisfied for ensuring safety, and confirmation items to be preferably satisfied for ensuring further safety of the storage structure.

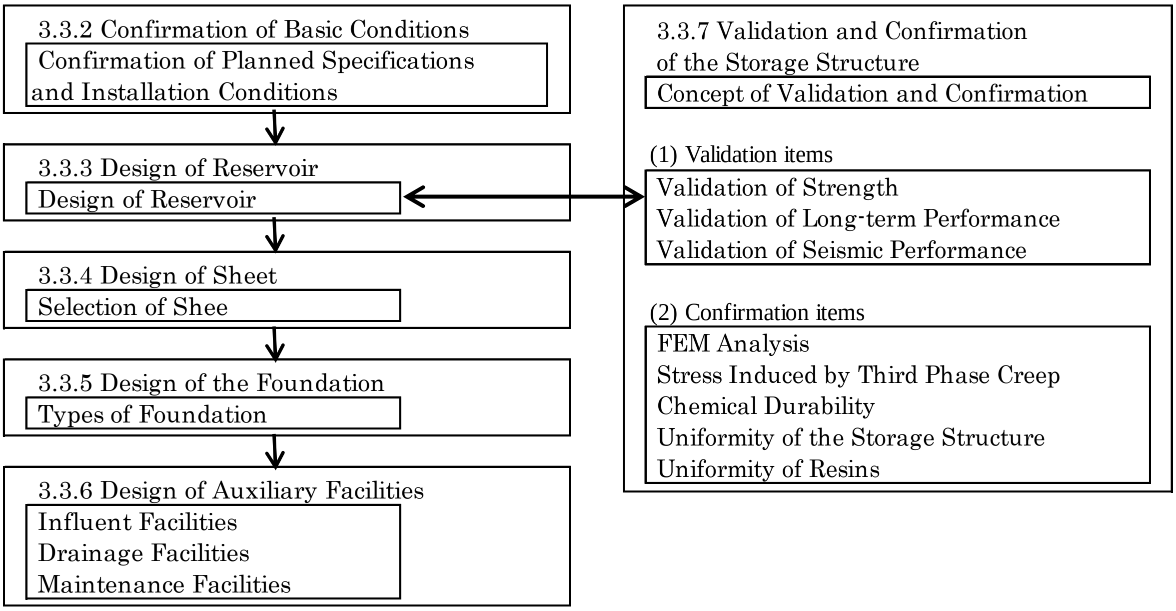


Figure 3.3-1 Procedures for Design of Facility

3.3.2 Confirmation of Basic Conditions

(1) Confirmation of Planned Specifications and Installation Conditions

For designing the Facility, it is required to confirm planned specifications and installation conditions based on the prior investigation and study. (1) Planned storage volume (2) Land where construction is feasible (3) Planned inflow height and planned drainage height (4) Conditions of the destination of drainage (5) Geological properties and groundwater level (6) Utilization status above the Facility (7) Foundation ground (8) Soil inflow volume, etc. (9) Rainwater inflow volume

(Commentary)
The Facility is outlined in Figure 3.3-2. For designing the Facility, confirm the planned specifications and installation conditions based on the preliminary survey and study.

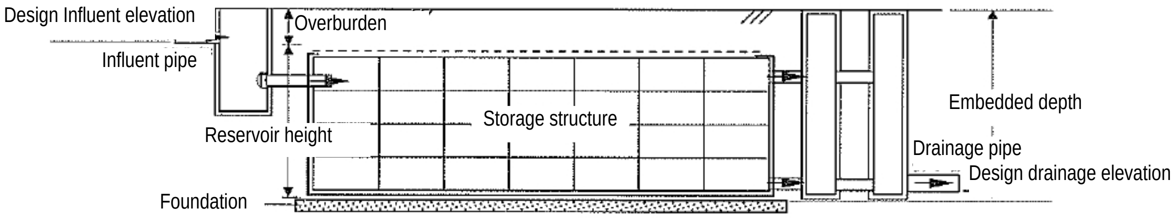


Figure 3.3-2 Outline of Facility

(1) Planned storage volume
Confirm the planned storage volume of the Facility, if it has been already calculated by hydrological design. However, the height and volume of the reservoir may be changed, in some cases, during confirmation process of the other planned specifications and installation conditions. In such a case, it is necessary to calculate again the effluent, etc. and suitably correct the planned storage volume.

(2) Land where construction is feasible
For layout planning of the Facility, geometrical properties (dimensions, etc.) of the land should be correctly grasped. It is also necessary to confirm requirements or restrictions, if any, with regard to the overburden, reservoir height or embedding depth.
The reservoir height in the scope of this manual is up to 4 m.

(3) Planned influent height and planned drainage height
Confirm the planned influent height (height of influent pipe bottom) and planned drainage height (height of drainage pipe bottom) for determining the embedding depth and reservoir height.

(4) Conditions of the destination of drainage
Confirm the conditions of the destination of drainage, such as drainage plan of the municipality concerned, drainage capacity of the existing piping on the downstream side.

(5) Geological properties and groundwater level
Confirm the geological properties and groundwater level, referring to the results of geological survey such as boring. This manual stipulates that the reservoir should be installed above the groundwater level. If the whole or part of the reservoir is installed below the groundwater level, which is out of the scope of this manual, there is risk of fracture of sheet or storage structure, due to external water pressures and buoyancy. It is therefore necessary to study case by case. If infiltration function is planned to be provided, infiltration capability of the soil must be surveyed, and the groundwater level is preferably at least 50 cm lower than the bottom end of the reservoir.

Standard items of geological and groundwater surveys are listed in Table 3.3-1 and Table 3.3-2.

Table 3.3-1 Geological Survey

Test item \ Survey item		Calculation of external force	Calculation of bearing capacity of foundation	Calculation of consolidation settlement
Boring			◎	◎
Sampling			◎	◎
Sounding	Standard penetration test		◎	
	Static cone penetration test		△	△
	Weight penetration test (Swedish sounding)		△	△
Physical test	Density test of soil particles	○	○	○
	Water content test	○	○	◎
	Grading analysis	○	○	○
	Liquid limit/plastic limit tests	○	○	◎
Mechanical tests	Unconfined compression test		◎	
	Triaxial compression test		◎	
	Consolidation test			◎
In-situ test	Wet density test of soil	◎		
	Plate loading test		◎	
	Coefficient of lateral subgrade reaction (K)		○	
Constants obtained		Unit weight ν	-Cohesion c -Shear resistance angle φ -Unconfined compressive strength q_U -N value	-Compression index C_C -Coefficient of consolidation C_V -Coefficient of volume compressibility m_v

(Source: "Recommendations for Road Earthworks - Culverts" (Japan Road Association))
◎: Especially effective survey method ○: Effective survey method △: Survey method used in some cases

Table 3.3-2 Groundwater Survey

Survey item	Survey purpose	Survey method
Determine groundwater level	-Existence of buoyancy -Impact on infiltration capability	-Measure the groundwater level using observation well, bored hole
Water quality survey	-Prevent clogging in the infiltration facility -Prevent pollution of groundwater and soil	-Conduct, if necessary, survey of influent water, groundwater and soil

Source: "Recommendations for Rainwater Infiltration Facility Engineering (draft) Survey and Planning (revised and enlarged version" (Association for Rainwater Storage and Infiltration Technology)

(6) Utilization status above the Facility
Confirm the utilization status above the Facility to determine superimposed load.

(7) Foundation ground
When it is anticipated that the foundation ground may not have sufficient bearing capacity, the installation place should be reviewed, or suitable measures should be taken, such as ground improvement, if necessary.

(8) Soil inflow volume, etc.
Correctly grasp the predicted accumulation volume and foreign material substance volume to determine the specifications of the influent facility such as grit chamber.

(9) Influent volume of rainwater
It is assumed that the rainwater influent volume has been calculated by hydrological design. Confirm the rainwater influent volume to determine the specifications of the influent facility. Design the necessary influent facility on the basis of set influent volume.

3.3.3 Design of Reservoir

The reservoir shall be designed by the following procedure.
(1) Determine the range available for installation
(2) Determine the planar geometry
(3) Overburden
(4) Determine the reservoir height
(5) Confirm the storage volume
(6) Measures for influent soil and foreign substances
(7) Calculate the design infiltration volume
(8) Validate and confirm the storage structure

(Commentary)
In the design of the reservoir, the planar geometry and reservoir height are determined on the basis of the land where construction is feasible, planned influent height, planned drainage height, etc., to confirm that the planned storage volume can be achieved.

(1) Determine the range available for installation
On the basis of the geometry of the site, the arrangement range in the land where construction is feasible is determined, with consideration given to construction margin width between temporary structures and reservoir, slope for carrying-in and work space.

As shown in Fig. 3.3-3, the reservoir should not be installed, in principle, in the range of 45 degrees from the end point of the building foundation. If it is impossible to install the reservoir apart from the building foundation, a retaining wall and/or sheet pile (permanent installation) should be placed to avoid impact of the lateral load.

Infiltration type reservoirs should preferably be installed with a horizontal distance from the foundation of building, etc., which is not less than double the reservoir water depth.

Reservoirs in the scope of this manual are lighter than concrete products, requiring, in many cases, no large construction machines for installation. However, if a construction machine such as truck crane and delivery truck is made to enter the excavated area, it is necessary to provide there a carrying-in slope and work space.

Since the facility is embedded by excavation, a necessary grade or earth retaining work should be provided on the excavated area, with margin width for performing the work.

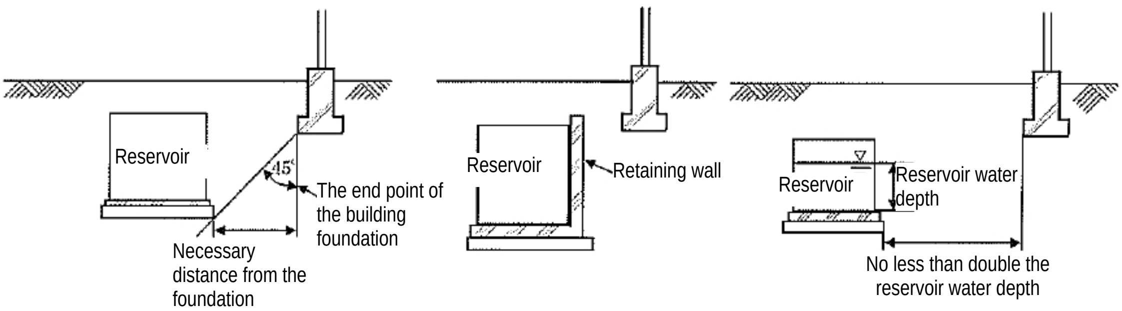


Figure 3.3-3 Consideration to adjacent foundation

(2) Determine the planar geometry
The suitable planar geometry of the reservoir should be determined, with consideration given to the size of reservoir, geometry of the site, status of the surroundings, arrangement of influent and effluent facilities, construction method, strength of the reservoir, seismic performance, existing buried objects,

maintenance, etc. The reservoir width should be determined on the basis of the validation result of the seismic performance.

(3) Overburden
The suitable overburden should be determined, in consideration of strength of the reservoir, pavement structure, use status on the surface and topography of the surroundings. The overburden should be as uniform as possible not to apply uneven loads on the storage structure.

The overburden disperses concentrated load of vehicle, etc. into the ground. This manual assumes that wheel load is uniformly distributed in the range of 45 degrees into the ground, according to the “Recommendations for Road Earthworks - Culverts” (Japan Road Association), and vehicle load (live load) should be validated based on this assumption.

In this manual, basically, the minimum overburden is set at 0.5 m and maximum overburden 2.0 m.

(4) Determine the storage height
The suitable storage height should be determined, on the basis of the planned storage volume, planned storage level and overflow depth, taking into consideration the overburden, planned drainage height, planned influent height, drainage method (gravity flow, pumped drainage), etc. The maximum reservoir height is set at 4 m in this manual.

(5) Confirm the storage volume
The reservoir size should be determined so that the effluent control volume given in the facility planning is achieved. When determining the size, the storage volume is converted by Equations (3.1) and (3.2) on the basis of net storage ratio of the reservoir.

$$V_w = Vrt \times \Pr \qquad \text{………………………….. (3.1)}$$

$$\Pr = \frac{(Vrt - Vm)}{Vrt} \times 100(\%) \qquad \text{………………………….. (3.2)}$$

where
V_W = storage volume (m^3)
Pr = net storage ratio (%)
V_{rt} = volume calculated from the outer dimensions *1 of the reservoir excluding the sheet
V_m = actual volume of storage structure, inspection hole, etc. in the reservoir (m^3)
*1 For calculating the planned storage volume, the storage depth may be used.

As shown in Fig. 3.3-4, the planned storage level is set at the height of the overflow pipe bottom, so that the volume of water stored below the planned storage level conforms to the planned storage volume.

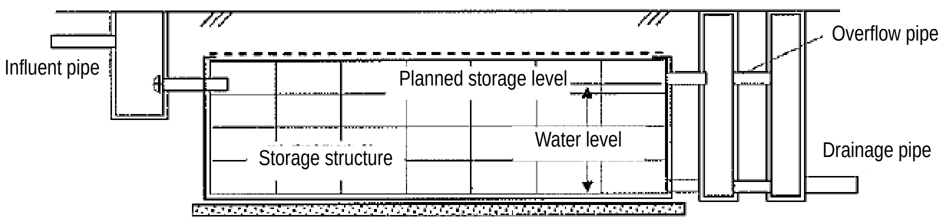


Figure 3.3-4 Planned Storage Level and Storage Water Level

(6) Measures for influent soil and foreign substances
Since the reservoir discussed in this manual is constructed mainly with plastic components about 50 to

100 cm long, it is difficult to remove sand, foreign substances, dust, etc. that have flowed into the reservoir. In many cases, since no grade is provided on the facility bottom, soil tends to accumulate. Therefore, the Facility structure should be designed with screen and grit chamber at the inflow section, to separate sand and foreign substances, preventing them from entering the reservoir.

(7) Calculation of the design infiltration rate
Calculation of the design infiltration rate assumes, in principle, use of concrete foundation. Infiltration through the bottom is, therefore, not expected. This manual considers, in principle, infiltration through the reservoir sides only. Fig. 3.3-5 shows the schematic diagram of the system. For calculation of infiltration rate through the sides, refer to the “Recommendations for Rainwater Infiltration Facility Engineering (draft) Survey and Planning (revised and enlarged version” (September 2006) (Association for Rainwater Storage and Infiltration Technology), etc.

Infiltration through the bottom may be calculated, at the discretion of the designer, referring to the recommendations, guidelines mentioned above, and manuals, etc., provided that suitable measures are taken.

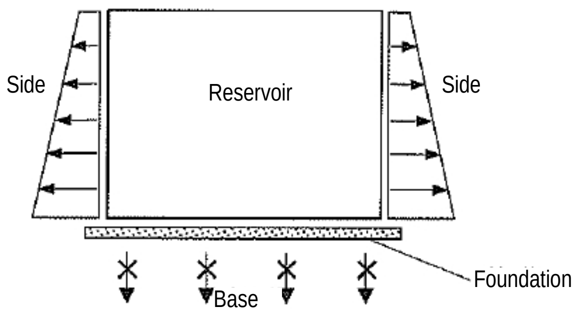


Figure 3.3-5 Infiltration from Facility (Image)

(8) Validation and confirmation of the storage structure
The storage structure used for the reservoir should have sufficient safety and durability so that the required function is provided under estimated external forces and in service conditions.

For ensuring satisfactory safety and durability of the reservoir, it is necessary to validate strength of the storage structure under vertical and horizontal directions, long-term performance and seismic performance.

For providing further safety of the reservoir, it is preferable to conduct FEM analysis, and confirm resistance to chemical impacts, etc.

For the method of validation and confirmation of the storage structure, refer to Section 7 of this chapter

3.3.4 Design of Sheet

For facilities for storage, water impermeable sheets (hereinafter “impermeable sheets”) are used, and for facilities for infiltration, water permeable sheets (hereinafter “permeable sheets”) are used.
(1) Selection of impermeable sheets
(2) Selection of permeable sheets
(3) Selection of protection sheets

(Commentary)
The Facilities are classified into two large categories, storage facility and infiltration facility.

For storage facilities, impermeable sheets and protections sheets are used, which are placed between the outer surface of the storage structure and surrounding ground.

For infiltration facilities, permeable sheets are used, which are placed between the outer surface of the storage structure and surrounding ground.

It is essential to select suitable sheets, because fracture of a sheet may impair storage and infiltration functions, and cause secondary disasters such as cave-in of the surface.

(1) Selection of impermeable sheets
Impermeable sheets should have sufficient strength, durability and water cutoff performance, for providing good storage function, without fracture under expected external forces and in service conditions.

The impermeable sheets are placed between the outer surface of the storage structure and surrounding ground. Usually, the storage structure is entirely covered with sheets without leaving interstices. To prevent fracture of the sheet, its outer surface is covered with protection sheets. If facture of the sheet is anticipated, because of the geometry of the storage facility, protection sheets are placed between the impermeable sheets and the storage structure. The upper surface is enveloped with permeable sheets in some cases for the intended purpose.

Since the reservoir is installed underground, very difficult work with open cut is necessary for reparation in case of failure of the water cutoff function.

1) Durability
For providing long-term durability of the impermeable sheet, both physical and chemical durability is required. Factors that influence physical durability include breakage due to rolling compaction of covering material during construction, fracture due to impacts, etc. during use of the surface, breakage due to intrusion of sharp edge stones or the like included in backfill soil, creep failure due to lateral earth pressures, etc. Chemical durability includes resistance to light and heat, chemical resistance, etc. Impermeable sheets must be selected considering these various factors.

Impermeable sheets used for storage facilities come in uniform sheets and compound sheets.

(2) Selection of permeable sheets
Permeable sheets are used for infiltration facilities. Permeable sheets should have sufficient strength, durability and water permeable performance, for providing good storage function, without fracture under expected external forces and in service conditions. When selecting permeable sheets, the following should be considered.

1) Water permeability
The permeable sheet should work to make rainwater in the reservoir swiftly permeate the ground and to prevent reverse flow of soil. The performance of the sheet is usually assessed by means of permeability coefficient.

The permeability coefficient of the sheet must be not less than the saturated permeability coefficient of the ground. As a general rule, it is preferable to select a sheet with permeability performance of 1.0×10^{-1} cm/s to 1.0×10^{-2} cm/s. Permeable sheets are woven fabric or non-woven fabric. For infiltration facilities, non-woven fabric sheets are preferably used, because of good permeability and other properties.

(2) Durability
For providing long-term durability of the permeable sheet, both physical and chemical durability is required. Factors that influence physical durability include breakage due to rolling compaction of

covering material during construction, fracture due to impacts, etc. during use of the surface, breakage due to intrusion of sharp edge stones or the like included in backfill soil, creep failure due to lateral earth pressures, etc. Chemical durability includes resistance to light and heat, chemical resistance, etc. Permeable sheets must be selected considering these various factors.

(3) Selection of protection sheets
Protection sheets are placed between impermeable sheets and surrounding ground, and between impermeable sheets and storage structure to prevent facture of the impermeable sheets. Protection sheets should have sufficient strength and durability to protect impermeable sheets. Protection sheets of the same kind of permeable sheets may be used. When selecting protection sheets, the following should be considered.

1) Durability
For providing long-term durability of the protection sheet, both physical and chemical durability is required. Factors that influence physical durability include breakage due to rolling compaction of covering material during construction, fracture due to impacts, etc. during use of the surface, breakage due to intrusion of sharp edge stones or the like included in backfill soil, creep failure due to lateral earth pressures, etc. Chemical durability includes resistance to light and heat, chemical resistance, etc. Impermeable sheets must be selected considering these various factors. Protection sheets are woven fabric or non-woven fabric.

2) Others
Protection sheets of the same kind of permeable sheets can be used. If ground of gravel or rock is excavated and used for backfilling, without any treatment, the protection sheet in contact with the excavated muck would break under loads during construction, superimposed load and earth pressures. In such a case, sand, etc. is used for backfilling, and additional sheets are placed, or thicker non-woven fabric is installed, to increase the strength of protection sheets.

For storage purpose, the permeability performance is not necessarily required of the protection sheet, and 10 mm thick rag opening felt type is used in some cases, which is employed for protecting the impermeable sheets for final disposal sites and coastal revetments.

3.3.5 Design of the Foundation

For surely supporting the reservoir, safety shall be confirmed in the design with regard to the following. (1) Ground (2) Liquefaction

(Commentary)
Foundations are classified into different types: concrete foundation, crushed stone foundation and sand foundation. The foundation for the reservoir discussed in this manual is in principle concrete foundation. However, for small size infiltration facilities, crushed stone foundation or sand foundation may be used, if sufficient bearing capacity of ground and evenness are ensured.

Reservoirs are constructed by lamination and coupling of plastic components. Therefore, to prevent displacement between components, the foundation should be free of unevenness and should be horizontal without gradient, and sufficient study should be conducted and measures should be taken for differential settlement.

(1) Ground
When designing and constructing a reservoir, it is essential to survey ground and groundwater, etc. at the installation site, for determining a suitable shape, dimensions and foundation type.

If weak stratum partially exists, measures shall be taken for achieving the design bearing capacity, such as replacement, ground improvement and pile foundation.

(2) Liquefaction
Possibility of liquefaction of ground in case of earthquake should be studied. If a risk of liquefaction is anticipated, the facility should not be installed in principle. If the facility is constructed in a place where there is a fear of liquefaction, sufficient measures should be taken, such as ground improvement.

3.3.6 Design of Auxiliary Facilities

(1) Influent Facilities

For achieving the required flow rate, influent facilities shall be suitably designed in terms of the following.
(1) Sectional area of influent connection pipe
(2) Installation height of influent pipe
(3) Influent chamber (grit chamber)
(4) Connection between storage structure and influent connection pipe
(5) Screen

(Commentary)
Influent facilities should safely introduce the planned rate of flow into the reservoir, and prevent inflow of soil, foreign substances, etc. For this purpose, the facilities should be designed adequately for the items below.

(1) Sectional area of influent connection pipe
The influent connection pipe should be a sectional area sufficient for the flow of planned rate, for surely introducing it into the reservoir. The sectional area should be determined by a suitable flow rate equation such as Manning formula.

(2) Installation height of influent pipe
The influent pipe bottom is set at a position higher than the water level at the time of maximum storage, for surely storing the planned water volume.

(3) Influent chamber (grit chamber)
When accumulated grits makes it impossible to fully use the effective volume of the reservoir, the grits should be removed immediately. However, grit removal in the reservoir is difficult to perform. The system should be designed with a grit chamber of the size suitably for the influent facility, to prevent soil from entering. For small facilities, grit pits may be effective for preventing inflow of soil, foreign substances, or the like.

(4) Connection between storage structure and influent connection pipe
The storage structure is connected with the influent connection pipe by means of a flexible coupling, if necessary.

(5) Screen
To avoid clogging of the orifices installed for preventing inflow of foreign substances into the reservoir and those installed in the drainage tank, screens are placed if necessary. The opening size of the screen is preferably determined depending upon the frequency of maintenance and kind of foreign substances contained in the rainwater inflow. Usually, the opening is 5 to 12 mm. For small inflow facilities, detachable pipe filters of the same diameter of the inflow connection pipe may be installed on the inflow tank side of the said pipe.

(2) Drainage Facilities

The drainage facilities should be designed properly for the items below, in order to ensure drainage at the required flow rate.
(1) Drainage system
(2) Design of orifice
(3) Connection between storage structure, effluent connection pipe and overflow pipe

(Commentary)
The drainage system should be determined suitably for the water level, etc. of the destination of water discharged. It is necessary to confirm the structure of downstream piping and flow capacity, to surely achieve the required discharge rate. For this purpose, the facilities should be designed adequately for the items below.

(1) Drainage system
The drainage system should be, in principle, gravity type. If drainage by gravity is difficult because of the water level, etc. of the destination, pumping discharge, or compound type by gravity and pumping is selected. The structure of the downstream piping of the destination and flow capacity should be confirmed, to achieve required discharge rate. Caution should be exercised to prevent, in particular, overflow because of filling up of the downstream piping.

1) Gravity flow system
The gravity flow system should be provided with a drainage tank equipped with drainage pipe, overflow pipe and orifice.

2) Pumping discharge system
The pumping discharge system should be provided with a drainage tank equipped with pump pit and pump as standard components. For the automatic pumping discharge system, in particular, the water level of the downstream piping at starting should be set meticulously.

(2) Design of orifice
When designing the orifice, the admissible discharge rate Q (m^3/sec) from the reservoir should be designed in such a manner that, in rainfall, the flow in the downstream piping is under the planned flow rate. Referring to the diagram in Fig. 3.3-6, the sectional area A of the orifice (m^2) is calculated in terms of the admissible discharge rate by Equation (3.3). Installation of screen should be planned, if necessary.

$$A = \frac{Q}{C\sqrt{2g(H - D/2)}} \qquad \text{……………………… (3.3)}$$

Where:
A = sectional area of orifice (m^2)
Q = admissible discharge rate (m^3/sec) C= flow rate coefficient (0.6)
H = water depth measured from the orifice bottom position (m)
D = height or diameter of orifice (m)
g = gravitational acceleration (9.8 m/s^2)

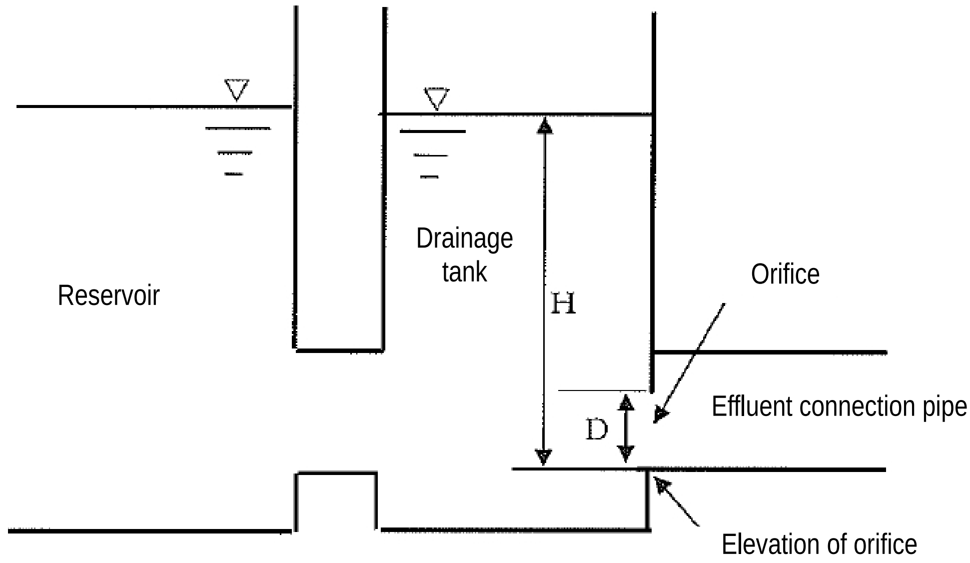


Figure 3.3-6 Explanation Drawing of Orifice

(3) Connection between storage structure, effluent connection pipe and overflow pipe
The effluent connection pipe and overflow pipe are connected with the storage structure by means of a flexible coupling, if necessary.

(3) Maintenance Facilities

The reservoir shall be provided with facilities for maintenance listed below according to necessity.
(1) Inspection hole
(2) Exhaust port
(3) Sign board

(Commentary)
Inspection holes should be installed according to necessity to confirm the grit accumulation in the reservoir, water volume and defects such as deformation of the facility. Exhaust holes should be provided according to necessity for removing the impact of compressed air produced by rainwater inflow.

The installation position and diameter of inspection holes and exhaust ports are restricted in some cases by the structure of the Facility and joint sections.

If an inspection hole(s) and an exhaust port(s) are installed in the reservoir, sufficient reinforcement should be provided, since some sections of the storage structure are removed. If a manhole is installed for inspection, measures should be taken to prevent the load of manhole and wheel loads through the manhole from directly applying on the reservoir (storage structure). An access step and/or a ladder for access of staff members to the reservoir inside should be resistant enough to corrosion, and foot supports, if installed, should be made of corrosion resistant materials such as steel (coated with resin), stainless steel, resin or the like.

(1) Inspection hole
Since the inspection hole is also used for cleaning, visibility to the reservoir bottom from the ground surface should be provided.

On the manhole cover, existence of the underground Facility should be indicated, with caution “Keep fire away,” etc.

(2) Exhaust port
The exhaust port should be structured suitably for the exhaust rate. It may be also used for inspection and drainage. In such a case, a cover that can release air pressure should be used. If the exhaust port is solely installed because it is impossible to install an inspection hole, measures should be taken on the outlet of the exhaust port to prevent clogging due to inflow of soil, etc.

(3) Sign board
When a reservoir is buried under school ground, park, plaza or the like where a large indefinite number of vehicles and citizens may enter, sign boards should preferably be installed, showing restriction of vehicle weight, prohibition of bonfire, etc.

Since there is a fear of fracture of the storage structure, sheet, etc. due to adjacent work, offset indication piles, etc. indicating the installation position should be preferably placed.

3.3.7 Validation and Confirmation of the Storage Structure

(1) Concept of Validation and Confirmation

When designing the reservoir, the performance of the storage facility shall be validated and confirmed. The designer should obtain necessary data of the storage structure from the manufacturer.
(1) Validation items
(2) Confirmation items

(Commentary)
Plastics are prone to change in properties from the initial performance during long-term service. Therefore, when designing the reservoir, performance should be validated and confirmed for various items such as strength and long-term performance of the storage structure, for ensuring safety. Plastics, even if designated by the same resin name, are microscopically different in molecular weight, molecular weight distribution and/or ingredients, etc., so they do not have the same characteristics in many cases. It is therefore preferable to conduct required evaluation of the quality of plastics of the storage structure, and to confirm the uniformity of resin.

Storage structures of different manufactures are different in structure and formed components. The designer must obtain necessary data from the manufacturer, and confirm that tests and evaluations are carried out in suitable conditions, by means of witness inspection, etc. according to necessity.

(1) Validation items
The requirements of Validation items should be necessarily satisfied for ensuring safety of the storage structure. The following items should be validated by the methods given in 3.3.7(2) to 3.3.7(4).
(i) Validation of strength (3.3.7(2))
(ii) Validation of long-term performance (3.3.7(3))
(iii) Validation of seismic performance (3.3.7(4))

The designer should suitably determine loads and external forces acting on the storage structure. Such loads and forces include, in normal conditions, dead load, live load, snow load, etc., and in the event of earthquake, seismic external force.

For normal loads, strength (3.3.7(2)) and long-term performance (3.3.7(3)) should be verified. Since, for concrete structures, creep usually poses no serious problem, it is not necessary to conduct validation for loads continuously acting. In contrast, with storage structures discussed in this manual, strain occurs due to creep under continuously acting loads for a long time. Long-term performance should be therefore verified.

The behavior of the structure in the case of earthquake should be conducted according to “Validation of seismic performance (3.3.7(4)).” Since the storage structure has a special configuration constructed with plastic components, shear deformation occurs in the reservoir at the time of earthquake.

This manual specifies that the manufacturer should perform alternating loading test and dynamic analysis assuming level 2 seismic motion to determine the magnitude of shear deformation under seismic forces, and the admissible reservoir width for different superimposed loads and reservoir heights respectively.

(2) Confirmation items
The requirements of confirmation items are preferably satisfied for ensuring further safety of the storage structure. These items are confirmed by the methods given in 3.3.7(5) to 3.3.7(9).
(i) FEM analysis (3.3.7(5))
(ii) Stress induced by third phase creep (3.3.7(6))
(iii) Chemical durability (3.3.7(7))
(iv) Uniformity of the storage structure (3.3.7(8))
(v) Uniformity of resin (3.3.7(9))

This manual includes, as a validation item for long-term performance, the method of determining strain. In addition, this manual discusses supplementary methods, as confirmation items, by FEM analysis and verification of stress inducing third phase creep.

See the test methods for verification items given in “Attachment”, and test methods for verification items in “References.”

(2) Validation of Strength

The storage structure, in the designed embedded conditions, shall be validated to have the strength necessary for withstanding vertical and horizontal loads borne underground by the said structure.
(1) Validation of the strength in the vertical direction
(2) Validation of the strength in the horizontal direction

(Commentary)
The strength of the storage structure is validated by comparing vertical and horizontal stresses induced underground in this structure with the admissible stresses determined by the structure strength test. In the vertical direction, stresses induced by dead and live loads are validated, and in the horizontal direction, stresses generated by lateral earth pressures, etc. are validated. In a certain environmental condition, snow loads, etc. are correctly calculated. If the stresses induced underground are smaller than the admissible stress for the storage structure, the construction with the designed overburden and embedding depth is determined to be possible.

If there is an anticipation that a load significantly different from the load used for strength validation may be applied to the reservoir temporarily during construction, further study should be conducted.

(1) Validation of the strength in the vertical direction
The embedded storage structure continuously receives loads of the covering material (dead loads) in the vertical direction. Above the embedded structure, the traffic of vehicles, etc. produces intermittent loads (live loads). The vertical loads acting upon the storage structure is schematically shown in Figure 3.3-7.

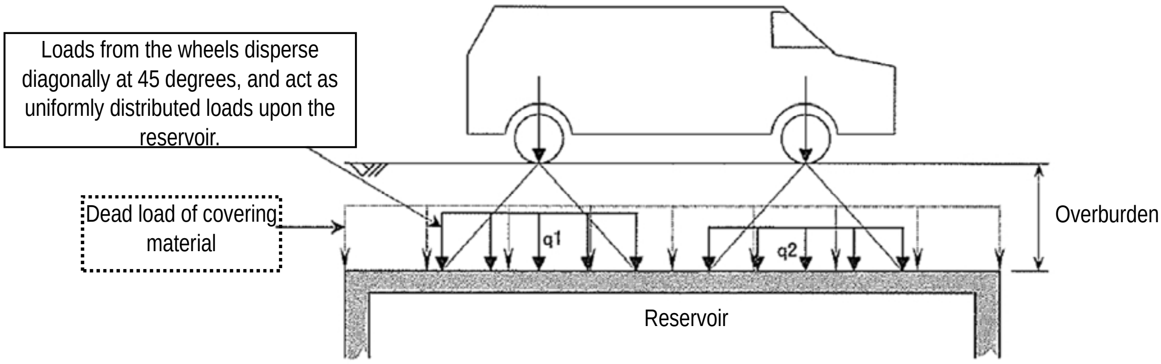


Figure 3.3-7 Model of Dead Loads and Loads of Vehicle (q1, q2)

These loads vary depending upon the design overburden. The structure must have a sufficient strength under the design overburden. The flow of validation process is shown in Figure 3.3-8.

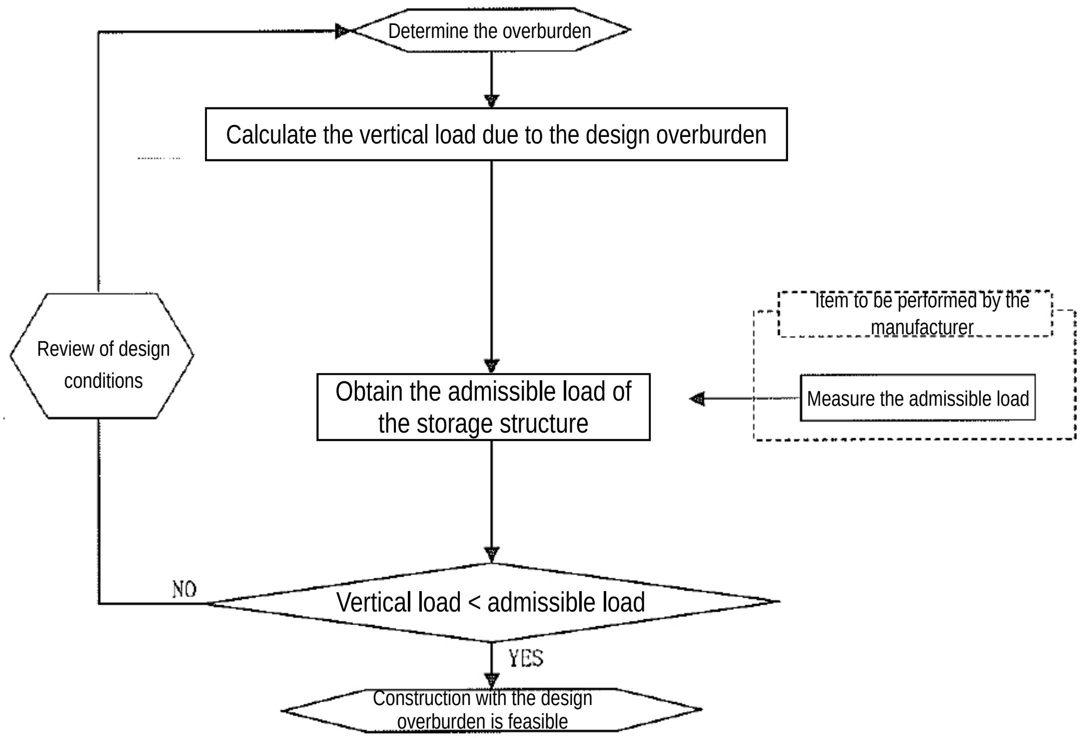


Figure 3.3-8 Flow of Strength Validation in the Vertical Direction

1) Dead load

Dead load should be correctly calculated, involving the overburden thickness and covering material. The unit weights of materials, that are basis for calculation, are shown in Table 3.3-3.

Table 3.3-3 Ordinary Unit Weight of Covering Materials*1

(unit: kN/m^3)

Material	Unit weight	Material	Unit weight
Reinforced concrete	24.5	Crushed stone (cobblestone)	22.6
Concrete	23.0	Soil (ordinary earth)	18.0
Asphalt concrete	22.5	Water	9.8

*1 Based on "Standard specifications for roads/bridges and commentary Part 1 Common requirements" and "Recommendations for Road Earthwork - Culverts" (Japan Road Association)"

2) Live load
This manual considers impact, assuming in principle vehicle load of T-25 (250 kN) as live load used in the strength validation.

(i) Calculation method of vehicle load
The vehicle load acting on the upper surface of the storage structure is discussed below.
Vehicle load is assumed to be applied in the traverse direction of road without restriction.
The load per unit length is given by Equation (3.4).

$$P_1 = \frac{2T_1}{B}(1+i) \quad , \quad P_2 = \frac{2T_2}{B}(1+i) \qquad \text{……………………… (3.4)}$$

where

P_1 = Live load of rear wheel of vehicle (kN/m)
P_2 = Live load of front wheel of vehicle (kN/m)
T_1 = Load of one rear wheel of vehicle (for T-25, T_1 = 100 kN)
T_2 = Load of one front wheel of vehicle (for T-25, T_2 = 25 kN)
B = Occupation of width of vehicle (B = 2.75 m)
i = Impact coefficient

The impact coefficient is 0.3 with overburden of 0.5 to 2.0 m in the application scope of this manual.

Table 3.3-4 Impact Coefficient[*1]

Overburden h_1 (m)	Impact coefficient
$h_1 \leq 3.5$	0.3
$3.5 < h_1$	0.0

*1 Source: "Recommendations for design and construction of parking lots, and commentary" (Japan Road Association)

Live loads due to wheel loads (load spreading from wheels) are assumed to disperse into the ground from the surface, diagonally at 45 degrees in the vehicle running direction from the ground contact width of 0.2 m.

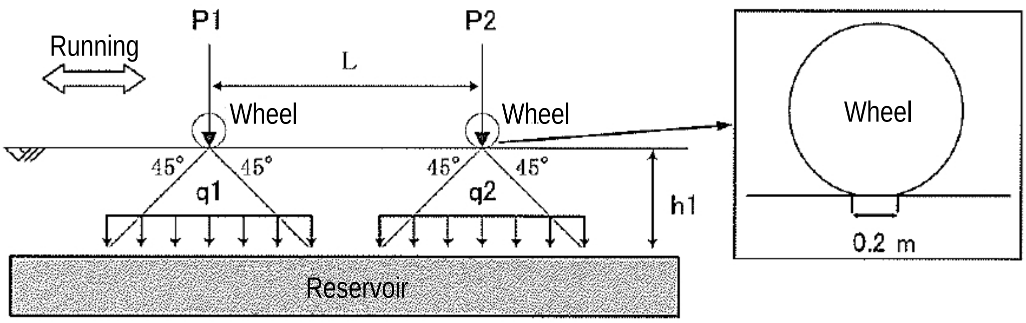


Figure 3.3-9 Schematic Diagram of Vehicle Load Distribution

The uniformly distributed load acting on the upper surface of the storage structure is given by Equation (3.5)

$$q_1 = \frac{P_1}{2 \cdot h_1 + 0.2} \quad , \quad q_2 = \frac{P_2}{2 \cdot h_1 + 0.2} \qquad \text{…………………………….. (3.5)}$$

where

q_1 = Uniformly distributed load of rear wheel of vehicle (kN/m^2)
q_2 = Uniformly distributed load of front wheel of vehicle (kN/m^2)

where

h_1 = Overburden (m)
P_1 = Load of rear wheel per unit length in the road transverse direction (kN/m)
P_2 = Load of front wheel per unit length in the road transverse direction (kN/m)
L = Center-to-center distance between front and rear wheels (wheelbase 4.0 m)

Given that

If L > 2 h_1 + 0.2, rear wheel load only is considered, then $q = q_1$
If L ≤ 2 h_1 + 0.2, rear and front wheel loads are considered, then $q = q_1 + q_2$

3) Validation method of vertical strength
Compare the vertical load (σ_A) with the admissible load ((σ_{vc}/γ) of the storage structure obtained from the manufacturer. Validation uses Equation (3.6).

$$\sigma_A < \sigma_{vc} / \gamma \quad \text{………………………… (3.6)}$$

where

σ_A = Vertical load (dead load + live load) (kN/m^2)
σ_{vc}= Hypothetical proportion limit stress (kN/m^2) in the vertical direction of the storage structure
γ = Material coefficient

(2) Validation of horizontal strength
The storage structure buried laterally receives horizontal loads due to earth pressures. In calculation of earth pressures in proportion to the embedding depth, this manual assumes, as a general rule, superimposed load of 10 kN/m^2 as live load. Although, ground water pressures, etc. are usually also considered, groundwater is not considered in this manual because this manual specifies that the reservoir should be installed above the groundwater level. Fig. 3.3-10 is a schematic diagram of horizontal loads applied to the storage structure. The storage structure should have a sufficient strength to withstand these loads. Fig. 3.3-11 shows the flow of validation.

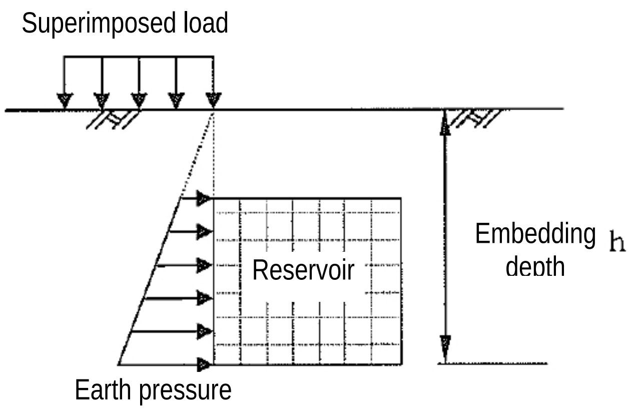


Figure 3.3-10 Schematic Diagram of Horizontal Loads Applied to The Storage structure

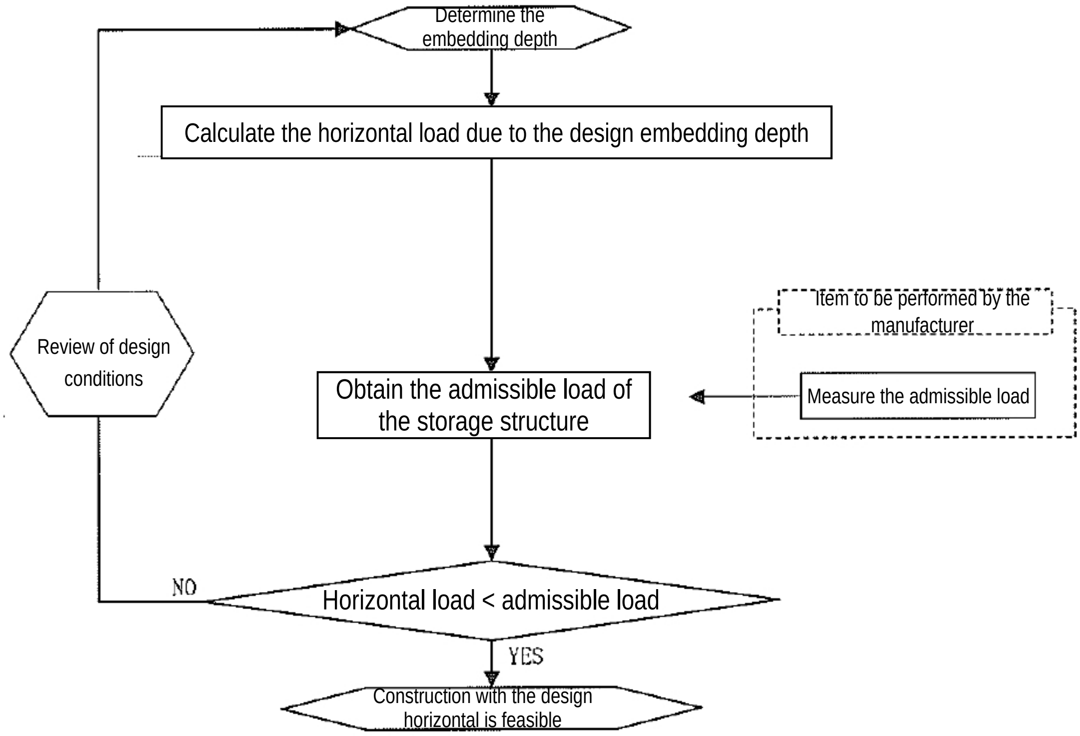


Figure 3.3-11 Flow of Validation of Horizontal Loads

1) Horizontal load

Horizontal loads to be considered are earth pressures. It is necessary to calculate earth pressure depending upon the embedding depth. For this calculation, in principle, superimposed load of 10 kN/m^2 is considered as live load in this manual. For design earth pressure for underground rigid structures such as box culvert, static earth pressure is usually used. For structures buried at a large depth for which displacement of side walls can be ignored, static earth pressure is also used.

The reservoir discussed in this manual is an underground structure, that flexible, composed of plastics. Therefore, it is possible to calculate earth pressure from active earth pressure in a case where the embedding depth is small. Based on the discussion above, in this manual, earth pressure is calculated from active earth pressure when the embedding depth is less than 4 m, and from earth pressure at rest when the embedding depth is 4 m or more.

(i) When embedding depth h (point of application of earth pressure to the reservoir) is less than 4 m

When the embedding depth is less than 4 m, influence of displacement due to flexible structure is anticipated, Coulomb's active earth pressure is therefore used (Equations (3.7) and (3.8)).

Sandy soil: …………….. (3.7)

Lean clay: $P_A = K_A \cdot r_s \cdot h - 2 \cdot c\sqrt{K_A} + K_A \cdot q$ (where $P_A \geqq 0$) …………….. (3.8)

$$K_A = \frac{\cos^2(\phi - \theta)}{\cos^2\theta\cos(\theta+\delta)\left[1+\sqrt{\dfrac{\sin(\phi+\delta)\sin(\phi-\alpha)}{\cos(\theta+\delta)\cos(\theta-\alpha)}}\right]^2}$$

(if sin(φ - α) < 0, sin (φ - α) is taken as zero) where

P_A = active earth pressure at depth h (kN/m^2)
K_A = Coulomb's active earth pressure
q = superimposed load usually applied (generally 10 kN/m^2)
h = depth where earth pressure (P_A) acts on the side surface (m)
γ_S= unit weight of earth (kN/m^3)
c = cohesion of soil (kN/m^3)
φ = angle of shear resistance of earth (rad)
α = angle between ground surface and horizontal plane (rad)
θ = angle between side surface of facility and vertical plane (rad)
δ = lateral friction angle between side surface of facility and earth ($\delta=\varphi/2$ according to the "Manual for Residential Area Disaster Prevention")

Soil property constants such as density of backfilling material and, shear resistance are used for calculating earth pressure.

These constant are preferably determined by on-site test or soil property test. However, if it is difficult to conduct ground survey because of various restrictions, the soil property constants given in Table 3.3-5 may be used.

Table 3.3-5 General Values of Soil Property Constant and Calculation Examples of Active Earth pressure coefficient (K_A)

Kind of backfilling soil	Unit weight (kN/m^3)	Shear resistance angle (φ)	Cohesion (C) *2)	Active earth pressure coefficient (K_A)
Gravelly soil*1)	20	35º	-	0.249
Sandy soil	19	30 º	-	0.301
Silt, cohesive soil (WL<50%)	18	25º	-	0.367

(Note) *1) The value of gravelly soil is used for clean sand.
*2) Calculation ignores cohesion C. (Since cohesion C works actually, slopes may exist, whose gradient is larger than the shear resistance angle φ.)

(ii) When embedding depth h (depth of the acting point of earth pressure on the reservoir) is 4 m or more
With embedding depth of 4 m or more, the ground is sufficiently stable. Therefore, static earth pressures are deemed to act on the side walls of reservoir.

$$P_h = Ko \cdot r_s \cdot h + Ko \cdot q \quad \text{.................................. (3.9)}$$

where

P_h= earth pressure at depth h (kN/m^2)
Ko = static earth pressure coefficient (0.5)
q = superimposed load usually applied (generally 10 kN/m^2)
γ_s= unit weight of earth (kN/m^3)

2) Validation of strength in the horizontal direction
Horizontal load (σ_B) determined in 1) is compared with the admissible value (σ_{hc}/γ) of the storage structure provided by the manufacturer. Validation is performed using Equation (3.10).

$$\sigma_B < \sigma hc / \gamma \quad \text{................................. (3.10)}$$

where

σ_B = horizontal load (kN/m^2)
σhc = hypothetical proportion limit stress (kN/m^2) in the horizontal direction of the

storage structure
γ= material factor

(3) Validation of Long-term Performance

Loads are continuously applied to the embedded storage structure. As the structure is made of plastics, it is necessary to consider strain due to creep. This is the reason why long-term performance under loads continuously applied shall be validated. (1) Vertical load (2) Horizontal load

(Commentary)
The storage structure continuously carries dead loads of covering material, etc. for a long time during service life. The storage structure discussed in this manual strains due to creep under continuous loads for a long time. It is necessary to validate the long-term performance under continuous loads. The strain induced under continuous loads for fifty years is determined by the long-term strain test for the storage structure given. For ensuring a long-term performance similar to that of sewage facilities, this manual sets the admissible strains in vertical and horizontal directions.

If the load continuously borne by the underground structure is not more than the load generating strain less than the admissible limit applied in the long-term strain test, it is determined that construction with the design overburden and at the embedding depth is feasible.

(Note) Since plastics tend to gradually change in quality during service for a long time, design of the structure must consider long-term performance. However, currently, the technique correctly evaluating performance for the long term of fifty years is still being developed. Under the circumstances, this manual basically adopts the validation by “strain” referring to the concept of various domestic standards for plastics that have been published.

(1) Vertical load
The storage structure continuously carries loads of covering material in proportion to the overburden. The admissible vertical strain under continuous loads was determined, for the purpose of avoiding adverse impacts upon daily life such as uneven settlement of the surface. The flow of validation process for long-term performance under vertical load is shown in Fig. 3.3-12.

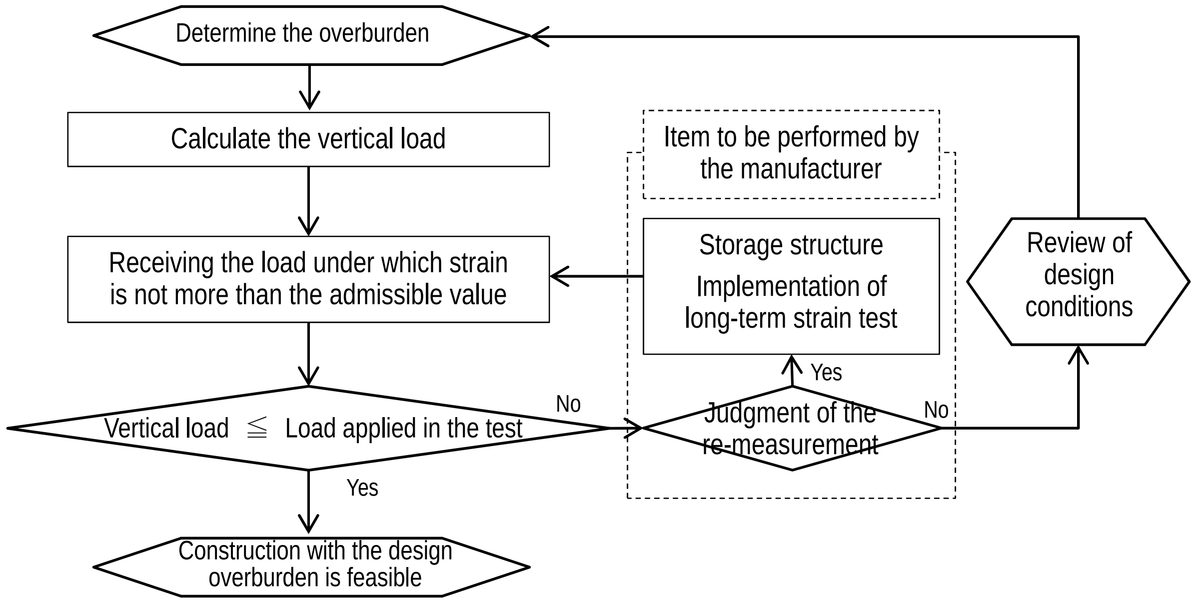


Figure 3.3-12 Flow of Validation Process for Long-Term Performance

The validation is conducted as follows.

(i) Setting the overburden and calculation of vertical load
Vertical load used in the validation of long-term performance considers, in principle, vertical load of covering material, continuously applied to the storage structure during its service life. However, for land where large loads other than the covering material may be induced, in a parking lot, for example, where heavy vehicles stay, superimposed load should be also considered.

(ii) Receiving long-term vertical strain test result of the storage structure from the manufacturer
It is necessary to be informed from the manufacturer of the vertical load under which strain obtained in the test is not more than the admissible value.

The load under which strain is not more than the admissible value is deemed as load that ensures satisfactory long-term performance, even if such load is applied to the storage structure for a long time. The admissible strain is set at 1%. For determining whether or not the magnitude of load in the test can be used for the load validation, the long-term strain of the storage structure in the vertical direction is verified using Equation (3.11).

Strain for the period equivalent to 50 years − strain after 10 hours ≤ 1 (% *1) ………. (3.11)

*1. The absolute value of vertical admissible strain is set at 4 cm that is the criterion for necessity of reparation of rutting for ordinary roads with small traffic volume (strain not more than 4 cm may be tolerable to some extent) (source: page 68 of "Guidelines for Maintenance and Reparation of Roads" (revised version)" July 1978 (Japan Road Association). The admissible strain is the ratio of this criterion (4 cm) to the maximum reservoir height 4 m considered in this manual.

(iii) Validation of load in the vertical direction
The vertical load used for validating the long-term performance is compared with the load applied in the long-term strain test of storage structure made by the manufacturer.

Vertical load used for validating the long-term performance ≤ Load applied in the long-term strain test of storage structure made by the manufacturer. ………………………………………… (3.12)

If both Equations (3.11) and (3.12) are satisfied, construction with the design overburden is determined to be feasible.

(2) Horizontal load
The underground storage structure is continuously subject to lateral earth pressures in the horizontal direction in proportion to the embedding depth. Horizontal strains induced by continuously applied loads were compared with vertical strains, to determine the admissible value so that no significant impact will be exerted upon the human life.

The flow of validation process for long-term performance under horizontal load is shown in Figure 3.3-13.

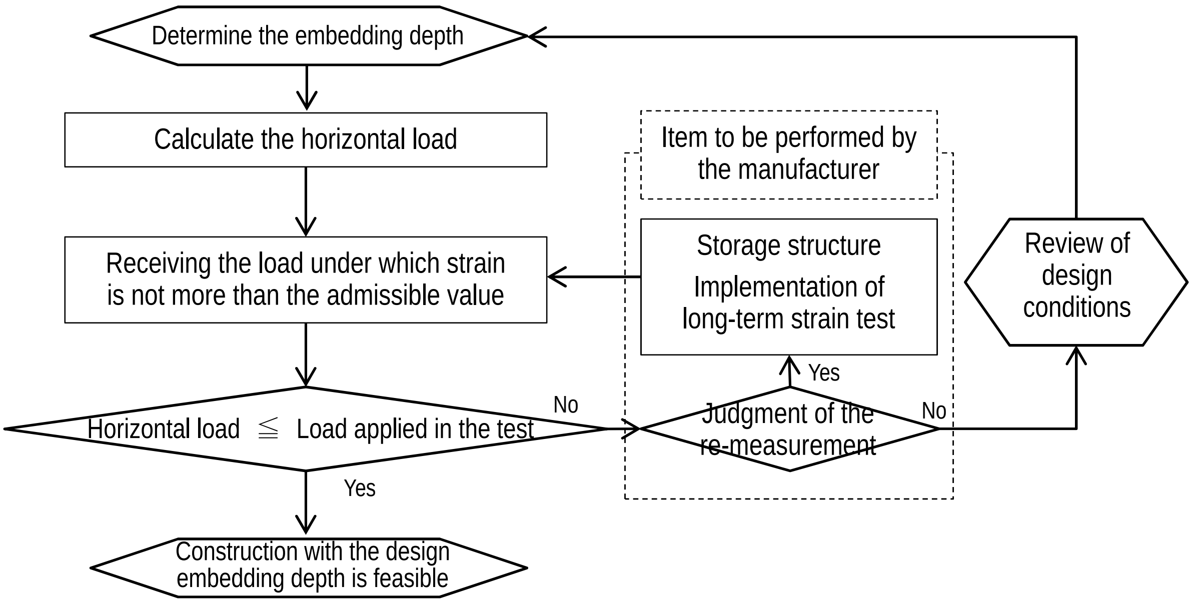


Figure 3.3-13 Flow of Validation Process for Long-Term Performance (horizontal load)

The validation is made as follows.

(i) Setting the embedding depth and calculating horizontal loads
For horizontal loads involved in the long-term performance validation, lateral earth pressures continuously acting during service life of the storage structure, in proportion to the embedding depth, are considered in principle. In this study, live loads are ignored.

However, for land where large loads may be induced, in a parking lot for example, where heavy vehicles stay, superimposed load, i.e., live load should be also considered.

(ii) Receiving long-term horizontal strain test results of the storage structure from the manufacturer
It is necessary to receive from the manufacturer the value of horizontal load that generates strain not larger than the admissible limit, given by the test.

As with vertical load, when strain not exceeding the admissible limit, under the horizontal load, even if it is applied continuously to the storage structure for a long period of time, satisfactory long-term performance is deemed to be achieved. To determine whether or not the magnitude of loading in the test can be used for load validation, the result of the horizontal long-term strain of the storage structure is validated by the use of Equation (3.13). Depending upon the configuration of the storage structure, Equation (3.14) may be used for validation.

Strain for the period equivalent to 50 years － strain after 10 hours ≤ 1 (%) (3.13)
Strain for the period equivalent to 50 years ≤ δhc[*1] (%) …………………………… (3.14)
*1: δhc=Hypothetical proportional limit stress in the horizontal direction

(iii) Validation of horizontal load
The horizontal load used for validating the long-term performance is compared with the load applied in the long-term strain test of the storage structure made by the manufacturer.
Horizontal load used for validating the long-term performance
≤ Load applied in the long-term strain test of the storage structure ……………… (3.15)

If Equation (3.13) or (3.14) is satisfied, and Equation (3.15) is satisfied, the construction at the design embedding depth is determined to be feasible.

(4) Validation of Seismic Performance

Since the buried storage structure undergoes shear deformation due to seismic motion, it shall be resistant to such deformation. Validation shall be conducted to determine whether or not the designed reservoir width is within the admissible width range obtained by alternating loading test and dynamic analysis assuming level 2 seismic motion.

(Commentary)
The reservoir is subject to seismic motion under the ground, generating shear deformation. The magnitude of shear deformation varies with overburden, height and width of the reservoir, and ground conditions, etc.

Figure 3.3-14 shows the flow of the validation for seismic performance. The dead loads (planned overburden 2.0 m and 0.5 m with ordinary soil) and the admissible reservoir width in relation to the reservoir height, assumed in this manual, are analyzed by a manufacturer. The designer should obtain the admissible reservoir width from the manufacturer, and compare it with the designed width. The validation uses Equation (3.16). If this equation is satisfied, the reservoir with the designed width is evaluated to be seismically resistant. The dynamic analysis should assume the Southern Hyogo Prefecture Earthquake in 1995 (the Great Hanshin Earthquake).

Designed reservoir width ≤ Admissible reservoir width analytically determined ……….. (3.16)
(provided that the following two conditions are satisfied:
design dead load ≤ load in the alternating loading test [*1]
design reservoir height ≤ reservoir height in alternating loading test [*2])
*1 This manual sets the maximum overburden at 2 m.
*2 This manual sets the maximum reservoir height at about 4 m

When the Facility is designed with an overburden and/or a reservoir height larger than the load with the maximum overburden and/or the maximum reservoir height, alternating loading test should be conducted in conditions more stringent than the design conditions to calculate the admissible reservoir width.

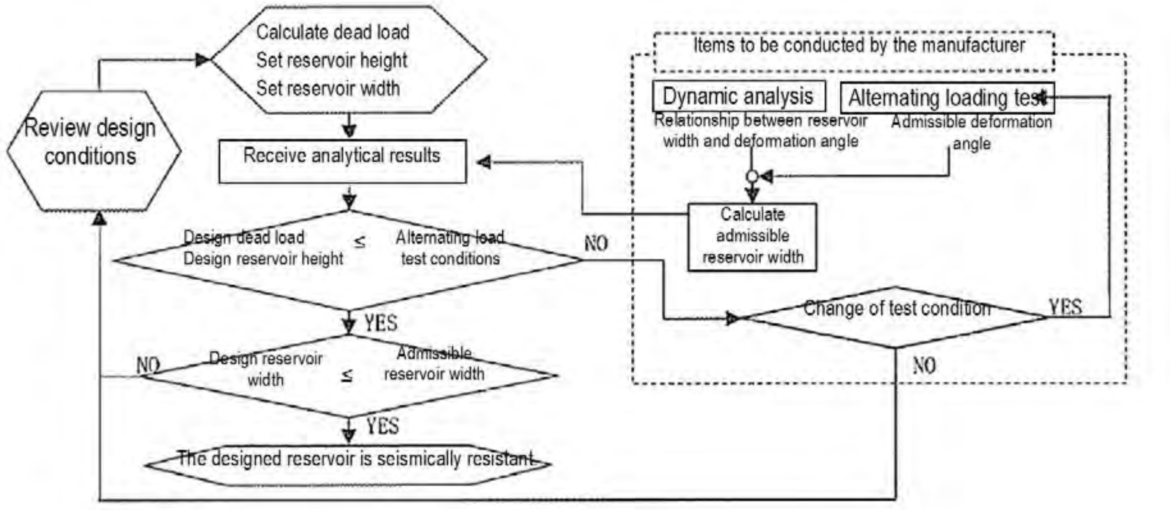


Figure 3.3-14 Validation Flow for Seismic Performance

(5) FEM Analysis

The following items shall be confirmed by FEM (finite element method) analysis to grasp the stress distribution in the storage structure. (1) Safety in terms of loads (2) Safety in terms of long-term creep

(Commentary)
Tensile stresses induced in the storage structure are preferably smaller than the tensile yield stress of the resin and stress generated in the third phase creep.
From this viewpoint, results of FEM analysis, tensile test and temperature accelerated test conducted by the manufacturer should be received to confirm safety in terms of load and third phase creep.

(1) Safety in terms of load
Confirm whether or not Equation (3.17) is satisfied. If not satisfied, there is a possibility that localized stresses may be induced in the storage structure, which are larger than the tensile yield stress of resin.
Maximum tensile stress given by FEM analysis < Tensile yield strength of resin determined by tensile test ………………………… (3.17)

*1: The tensile yield stress is the value given in JIS K 7113.

(2) Safety in terms of long-term creep
Confirm whether or not Equations (3.18) and (3.19) are satisfied. If these equations are satisfied, localized stresses may not occur, which are larger than the stress generating third phase creep for the period equivalent to 50 years.

Maximum tensile stress given by FEM analysis < Tensile yield strength of resin determined by tensile test/4*2 ………………………… (3.18)

Maximum tensile stress given by FEM analysis < Stress generating third phase creep for the period equivalent to 50 year service in temperature accelerated test*4 ……………………………. (3.19)

*2: See the safety ratio given in "Study report of technological feasibility of seismic reservoirs, etc. made of new material (FRP), March 2000 (Fire Equipment and Safety Center of Japan)
*3: Third phase creep is described in §20 and References 3.
*4: For calculation method, see References 3.

(6) Stress Induced by Third Phase Creep

When validating long-term performance, strain for a period equivalent to 50 year service is assumed by exploration. Study shall be made to confirm whether or not, in the exploration period, strain begins to increase significantly. For estimating behavior of plastics, the magnitude of stress is determined on the basis of the strain-time curve, which produces third phase creep for a period equivalent to 50 year service at normal temperature, FEM analysis is made to confirm that no localized stress is induced, which exceeds the admissible stress of the storage structure.

(Commentary)
Usually, plastics undergo creep phenomenon under loads continuously applied for a long time. Figure 3.3-15 shows strain-time relationship for plastics continuously carrying load. Creep phenomenon is divided into three phases; in the first phase of creep, after instantaneous strain occurs, the strain rate gradually decreases, and in the second phase, strain rate becomes constant, and in the third phase, strain rate abruptly increases. In §17, it is stipulated that, for validating long-term performance, strain for the period equivalent to 50 year service is estimated by exploration from the strain data up to 1,000 hours. For linear estimation in the exploration period, the behavior should be the second phase creep in which strain increases at an almost constant ratio. Since it takes a long time to measure the behavior at normal temperature for the exploration period (1,000 hours or more), temperature accelerated test is conducted. Manufacturers (test laboratories) should conduct the test by the method given in Reference 3. By imputing the value obtained in the test into Equation (3.19), confirmation should be made to determine whether or not stress is induced locally in the storage structure, whose magnitude is equal or superior to stress generating the third phase creep for the period equivalent to 50 year service at normal temperature.

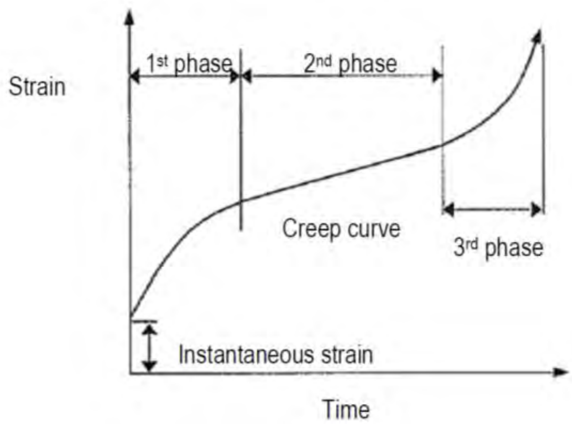


Figure 3.3-15 Strain-to-time Relationship of Plastics

(7) Chemical Durability

Chemical durability shall be confirmed for the following points in order to ensure the required performance of the storage structure.
(1) Chemical resistance
(2) Light resistance
(3) Heat aging resistance and low temperature resistance

(Commentary)
The storage structure, as rainwater storage and infiltration facility, is expected be subject to sunlight and temperature change from manufacture at the factory to completion of embedding. During service, the facility is continuously influenced by influent water quality. Since the facility is required to maintain the required strength in such environment, evaluation results for the following items shall be

received to confirm that the management criteria set by the manufacturer are satisfied.

(1) Chemical resistance
Since rainwater intermittently flows into and is stored in the reservoir during service, the reservoir is continuously influenced by the quality of inflow water. Confirm that the storage structure shows almost no deterioration due to water quality. The evaluation result is presented by the manufacturer, by means of the change in mass of the specimen before and after chemical immersion test and change in physical properties such as elongation.

(2) Light resistance
The storage structure may be subject to sunlight from manufacture at the factory to completion of embedding. Confirm that, even when exposed to sunlight, no change from initial performance occurs. Evaluation should use the light source, and the evaluation result is presented by the manufacturer by means of change ratio in physical properties such as tensile yield stress and elongation of the specimen before and after exposure to the light source.

(3) Heat aging resistance and low temperature resistance
The storage structure may be subject to temperature change from manufacture at the factory to completion of embedding. Confirm that, even in such a condition, no change from initial performance occurs. Evaluation should use the temperature conditions, and the evaluation result is presented by the manufacturer by means of change ratio in physical properties such as tensile yield stress and elongation of the specimen before and after exposure to temperature changes.

(8) Uniformity of the Storage Structure

For the purpose of ensuring predetermined performance of the storage structure in terms of strength and long-term performance, the items specified below shall be examined with respect to quality uniformity of their components.
(1) Mass
(2) Dimensions

(Commentary)
Components may vary in mass or dimensions with the molding conditions or the mold used in production. This variance may affect the strength and the long-term performance of the structure. It is therefore imperative to examine uniformity of quality in terms of mass and dimensions. To check the uniformity in quality, results of measuring mass and dimensions shall be obtained from manufacturers to verify that they meet the management standards defined by the manufacturers.

Manufacturers shall regularly sample different production lots and measure their characteristics to check the uniformity. They shall carry out the measurement as needed so that they can be ready to submit the measurement results of the products delivered upon request from the designer. Actual measurements shall be performed by manufactures or third-party test centers.

(1) Mass
The mass of a component shall be examined to verify uniformity in the storage structure. At least three samples need to be tested. As regards the products mentioned in this manual, components with exterior dimensions of 300 mm and more shall meet the requirement of a deviation within the range of +/- 3.0%.

(2) Dimensions
The mass of a component shall be examined to verify uniformity in the storage structure At least three samples need to be tested.

(9) Uniformity of Resins

For the purpose of ensuring predetermined performance of resins used as molding materials for the storage structure, the items specified below shall be examined with respect to uniformity.
(1) Strength
(2) Density
(3) Melt flow rate (MFR)
(4) Data related to grades and resin uniformity

(Commentary)
Two different kinds of resins are used as molding materials for the storage structure. One is virgin resins and the other is recycled resins.

Virgin resins refer to resins newly produced through synthesis by resin manufacturers. They control synthesizing methods and conditions to produce resins of constant quality. This means that the same type and grade of virgin resins are thought to have a high level of uniformity. In many cases, virgin resins are supplied in a granular form, called pellet.

Recycled resins refer to resins reused after they are once processed into a form of product in the molding process. As they undergo a molding process each time they are reused, they receive a thermal history each time. Generally, virgin resins are added with thermal stabilizer for prevention of thermal deterioration due to processing. With respect to recycled resins, it is thinkable that thermal stabilizer is deteriorated or reduced after they receive more thermal histories than virgin resins. In addition, it is possible that recycled resins may be a mixture of different grades of resins, given that, in many cases, different molded products are crushed or mixed and remolded into pellets to be supplied to manufacturers. Therefore, they require particular attention to quality uniformity.

Manufacturers have to be aware of how resins are collected for recycling and to quantify the quality of resins to be delivered. It is desirable to carry out the test for each product lot. They shall carry out the measurement as needed so that they can be ready to submit the measurement results of the products delivered upon request from the designer.

Should any foreign substance be mixed into resins, it may affect the molding machine and the storage structure. A visual inspection shall be performed to make sure that no foreign substance is mixed in.
The contractor should confirm that the resins meet the management standards for the uniformity defined by manufacturers.

(1) Strength
Since the strength of plastics cannot be evaluated when they take the form of a molding such as pellet and powder, the contractor is recommended, for confirmation of strength, to obtain the results of evaluation by using the specimens of a form of dumbbell which are produced according to JIS K7139. The test to be conducted shall be a tensile test to confirm the results according to JIS K7161, JIS K7162 and JIS K7113. The number of specimens shall be three or more.

(2) Density
The density should be checked for by obtaining the results by JIS K7112. The number of specimens should be 3 or more.

(3) MFR (Melt Flow Rate)
MFR is an index for the flow rate of resins. The smaller the value is, the smaller the fluidity. The contractor is recommended to obtain the results according to JIS K7210.

(4) Product numbers and related data on the homogeneity of resins
With regard to virgin resins, their quality can be identified to be the same when their numbers are the

same. In order to check the products for whether they are the same in the use of resins, the contractor is recommended to obtain their product numbers.

In the case of recycled resins, their product numbers cannot sometimes be identified, the designer is recommended to obtain the homogeneity data of resigns, from recycled resins manufacturers (supplier), including mill sheets (inspection result reports), history of resign recycle, characteristics of resigns, etc.

3.4 Construction

3.4.1 Construction Plan

(1) Formulation of a Construction Plan

In formulating a construction plan for the Facility, the following matters shall be taken into consideration in a comprehensive manner: purpose of the Facility, topography, geology and other natural conditions of the terrain, other relevant works, underground installations, construction work safety measures, environmental conservation measures, etc.

(Commentary)
The contractor shall draw up a construction plan pursuant to the design documents describing the procedures and construction methods required in order to complete the Facility. In cases when it is difficult to formulate such a plan based on the design documents because of specific worksite conditions or other factors, the contractor shall discuss the matter with the owner and shall receive necessary instructions.

In the event that changes to the construction plan arise in the process of construction work, the contractor shall create a revised construction plan. Below is a list of the major items organized in the formulation of a construction plan.

(1) Outline of construction work
Items determined in the design documents.

(2) Organization of the worksite
(i) Worksite representative, chief engineer or managing engineer, safety officer, and other chief engineers or officers as stipulated in relevant laws and ordinances
(ii) Communication system and safety control mechanisms for emergency situations, construction liaison committee composed of relevant parties to the construction management contractor
(iii) Measures for emergency situations, such as earthquake warnings, etc., and materials and equipment for emergency situations

(3) Material plan
Classification of the periods for scheduled use of materials and for purchase of materials into the categories of temporary construction and main construction.

(4) Temporary construction plan
Worksite office, material storage, electric power receiving facilities and personnel in charge of their handling, water supply facilities, drainage facilities.

(5) Plan of construction methods and construction equipment
(i) Earth retaining – the plan shall display graphically, through diagrams, a cross-section of the construction area, as well as structures, locations, work methods and equipment for each type of earth retaining work, and shall include stress computation documents.
(ii) Earth works – the plan shall stipulate excavation locations, work methods, routes for

transportation of muck during construction work, locations for temporary storage of such soil, destinations for transportation of muck and sludge generated during construction work (address, ownership), and materials and methods for backfilling work.

(iii) Dewatering works – the plan shall display graphically, through diagrams, destinations of drainage, as well as capacity, number, and installation locations of pumps.

(iv) Construction work of the facility – the plan shall display graphically, through diagrams, the materials for construction of reservoirs, foundations, auxiliary facilities, etc., and construction procedures, etc.

(v) Concrete works – the plan shall display graphically, through diagrams, the types of concrete, placement methods and classification, curing, location of joining areas, forms and supports, processing methods for reinforcing bars, etc.

(vi) Ground improvement works – the plan shall stipulate the scope and work methods for ground improvement

(vii) Other – the plan shall stipulate other specific work methods

(6) Plan of temporary construction work

(i) Construction of temporary piers, work platforms, etc. (structures to support heavy objects shall be displayed through structural diagrams and stress computation documents)

(ii) Temporary sidewalks, temporary roads (the plan shall display graphically, through diagrams, locations and structures)

(7) Process control plan

(i) Process table of the overall construction and detailed tables by operation

(ii) The process tables shall be created using networks and bar charts

(8) Plan for quality control

The plan shall cover inspection on acceptance of materials, and shall include photographs of construction records.

(9) As-built management plan

The plan shall outline methods that meet the as-built management standards and as-built management tables.

(10) Safety control plan

(i) Disaster prevention measures in line with the Recommendations for Safety in Civil Engineering Works, etc.

(ii) An outline of safety facilities, location of traffic guides, and safety measures

(iii) Methods for safety education for employees and workers

(iv) Measures for prevention of impact of construction work on underground installations, above-ground installations, residential buildings, etc.

(v) Contact information, systems for mobilization of human resources, and procurement of materials and equipment in cases of emergency

(vi) Measures for prevention of oxygen deficiency and toxic gases, safety equipment, operations chiefs of work involving second-class danger of oxygen-deficient air.

(11) Plan for promotion of utilization of recycled materials

The plan shall outline the types of construction byproducts, recycling methods, the names of companies specializing in transportation and disposal, and separation of waste at the construction site.

(12) Plan of environmental measures

(i) Methods for prevention of noise, vibration, foundation settlement, dust, etc.; dangerous objects

(ii) Measures for prevention of use of unauthorized light oil in construction machinery (powered by diesel engines)

(2) Advance Surveys and Preparation

Advance surveys shall be implemented on the matters outlined below in line with the conditions at the construction site.
(1) Onsite surveys and measurements
(2) Surveys of underground installations
(3) Confirmation of existing structures and other obstructions
(4) Other

(Commentary)
Advance surveys are indispensable for the formulation of a construction plan. They must be conducted on the sites where the Facility will be constructed and the surrounding areas, together with thorough preparation in order to avoid obstructions to the launch of work.

(1) Onsite surveys and measurements
Onsite surveys shall be implemented in order to confirm the topography and geology of the construction site, the presence of wells in the surrounding area, and the possible impact on residential buildings.
The contractor shall conduct plane-table surveys and control-point surveys to confirm the local conditions, and shall establish in advance control points in order to determine the reference height and the construction locations.
The contractor shall also confirm the groundwater level at the construction site, and shall thoroughly examine measures to deal with groundwater during construction and their impact on the surrounding area after completion of construction. In construction of infiltration facilities, if groundwater is confirmed beneath their bottom, the contractor shall consider methods for reducing the underground depth of construction.

(2) Surveys of underground installations
It is necessary to conduct thorough advance surveys of the location, scale, structure, and degree of obsolescence of lifeline underground installations, including gas pipes, waterworks pipes, sewage pipes, communication cables, power lines, etc., and to take measures to secure their safety.

(3) Confirmation of existing structures and other obstructions
The contractor shall implement surveys to examine the possible presence of existing structures, such as buildings, trees, and aerial lines that would obstruct construction of the Facility, and shall hold discussions with the supervisor.

(4) Other
The contractor shall conduct preparations with consideration of the following items because of their importance for the formulation of the construction plan.
(i) Relevant laws and regulations
(ii) Procedures at public offices
(iii) Verification of design documents
(iv) Survey reports regarding the environment of the surrounding area
(v) Groundwater level survey reports
(vi) Provision of information and explanation of construction work to residents of the surrounding areas

3.4.2 Construction Methods

(1) Construction Procedure

In the implementation of construction work of the Facility, the contractor shall thoroughly comprehend and adhere to the construction procedures, and shall strive to ensure safe and smooth construction work.

(Commentary)
The standard workflow for construction of the Facility is displayed in Figure 3.4-1. Photo 3.4-1 demonstrates examples of various construction operations. This section provides details on the operations highlighted in the boxes.

Workflow	Section
Construction Plan	3.4.1(1) Formulation of a Construction Plan
↓	
Rigger	3.4.1(2) Advance Surveys and Preparation
↓	
Temporary works	3.4.2(2) Earth Retaining Work
↓	
Excavation Work	3.4.2(3) Excavation Work
↓	
Foundation Work	3.4.2(4) Foundation Work
↓	
Assembly Work	3.4.2(5) Assembly Work Procedure 3.4.2(6) Assembly of Storage Structures 3.4.2(7) Placement of Sheets
↓	
Backfilling Work	3.4.2(7) Backfilling Work, 3.4.2(7) Compacting Work
↓	
Removal Work	3.4.2(2) Earth Retaining Work
↓	
Grading	
↓	
Clear-Out	

Figure 3.4-1 Standard Workflow for Construction

1) Excavation Work, Placement of Sheets work

2) Assembly of Storage Structures (condition)

3) Assembly of Storage Structures (Completed)

4) Placement of Sheets Work

Photo 3.4-1 Demonstrates Examples of Various Construction Operations

(2) Earth Retaining Work

The contractor shall implement earth retaining work in line with a temporary construction plan that includes the items below, while striving to secure the safety of work (1) Selection of earth retaining work (2) Building of earth retaining supports (3) Removal of earth retaining supports

(Commentary)
Earth retaining work shall be implemented in a safe manner, pursuant to relevant standards.

(1) Selection of earth retaining work
In principle, earth retaining work shall be implemented in all construction projects in which the depth of excavation exceeds 1.5m. Exception shall be made only in cases, in which it is possible to implement excavation work while maintaining a gradient that matches the geology of the specific location. It is recommended to maintain a distance of 1.0m between the front of the earth retaining wall and the sides of the reservoir in order to maintain workability in assembly and backfilling operations.

1) The most common methods for earth retaining are simple earth retaining, earth retaining using guide piles and horizontal sheeting, earth retaining using steel sheeting, etc. The contractor shall select the most appropriate method taking into consideration the earth conditions, groundwater levels, excavation depth, impact on the surrounding area, etc.

2) In cases when the Facility is of a large scale and excavation from the ground surface is difficult, earth retaining work is often implemented at the base of excavation. In such cases, it is necessary to select an earth retaining method that does not obstruct crane operations, such as slope excavation and free-standing work, avoiding bracing work.

(2) Building of earth retaining supports
The pressure applied on earth retaining walls increases over time after excavation, and it may result in swelling of the retaining wall or foundation settlement in the backside of the retaining wall. In order to prevent such happenings, earth retaining supports must be built promptly after the completion of excavation at the designated locations.

The contractor shall install support materials in a manner that will force the retaining walls and the supports to stick together, taking care to avoid loosening and uneven loading. In cases when the Facility is of substantial height and the distance from the base of excavation to the top of the Facility exceeds 3.0m, the vertical distance from the base of excavation to the lowest brace increases, so the contractor shall implement thorough examination of the safety of the structure.

(3) Removal of earth retaining supports
When the reservoir assembly and the backfilling work reach a certain height, earth retaining supports shall be removed using methods determined in advance in order to avoid applying excessive pressure on the retaining wall. When removing earth retaining materials, the contractor shall exercise due care to avoid transferring the vibrations to the main structure of the Facility.

(3) Excavation Work

The contractor shall implement excavation work with sufficient consideration to the following items.
(1) Excavation procedure
(2) Excavation width
(3) Excavation surface
(4) Excavation equipment
(5) Drainage
(6) Handling of muck

(Commentary)
The contractor shall implement excavation work in a precise manner, based on the design documents, in order to avoid unnecessarily deep or wide excavation.

(1) Excavation procedure
It is recommended to implement excavation work symmetrically on both sides in order to avoid applying uneven earth pressure, and from the central part outward in order to minimize as much as possible the period in which the structure is in a disadvantageous position in terms of applied stress due to the frontal opening of the earth retaining wall.

(2) Excavation width
When installing supports, it is recommended to implement excavation work taking care not to exceed the planned excavation width (see Fig. 3.4-2), and to maintain a distance of 1.0m between the front of the earth retaining wall and the sides of the reservoir in order to maintain workability in assembly and backfilling operations.

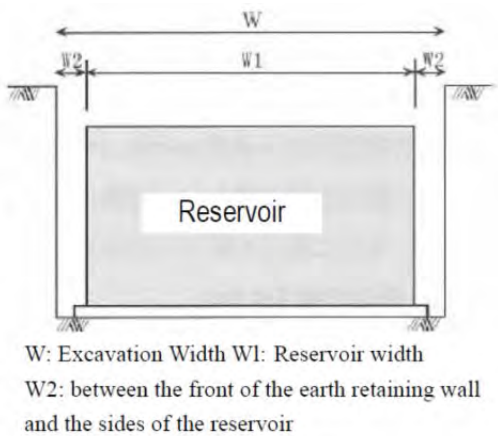


Figure 3.4-2 Excavation Width

(3) Excavation surface
In excavation work, the contractor shall strive to minimize the negative impact on the natural ground and to avoid the occurrence of irregularities in the terrain. In cases when the presence of stagnant water or spring water is confirmed on the excavation surface, the contractor shall implement

appropriate measures to deal with the issue, and overall shall strive to maintain the excavation surface in a good condition throughout the construction work.
When implementing leveling work for foundation, in particular, the contractor shall not disturb the bearing (foundation) surface. Also, the contractor shall avoid as much as possible implementing excavation work in rainy weather.

Condition of Excavation Work

(4) Excavation equipment
Excavation equipment shall be selected in view of the surrounding conditions. In cases when excavation work is implemented in the vicinity of private homes, in particular, the contractor shall select excavation equipment with a small impact on the surrounding environment in terms of noise, vibration, etc.
In the case of excavation in areas with existing underground installations, the contractor shall carry out manual excavation work while confirming the positions of the underground installations, and shall provide protection to the exposed installations if necessary in order to guard them from damage.

(5) Drainage
When the presence of spring water, etc., is confirmed in the excavation area, the contractor shall consider measures to prevent foundation settlement due to drainage and contamination, etc.

During reservoir assembly work and backfilling work, the contractor shall apply sump drainage to ensure that water does not collect in the excavation area, and shall maintain good working conditions. Excavation amidst bad drainage conditions will not only reduce the effectiveness of excavation work, but will also have negative impact on the quality of the reservoir. Furthermore, it will lead to formation of mud, and will eventually hinder operations for treatment of muck. Therefore, the contractor must exercise due care when working in such conditions.

As for the drainage during excavation work, the contractor shall discuss with relevant supervising entities clearance conditions regarding contamination and drainage water volume. As for discharge of wastewater into rivers or sewage facilities, the contractor shall adhere to the stipulations of the Water Pollution Control Act and other relevant regulations and ordinances, and shall treat wastewater in keeping with the clearance conditions by settling and filtrating contaminated water in order to ensure that the discharged water contains no sand and earth.

(6) Handling of muck
The contractor shall give consideration to the following items in cases when earth generated during excavation of the ground is to be stored on the construction site.
1) The contractor shall secure space for storing muck, and shall store it in the designated location.
2) The contractor shall ensure that stored earth does not disperse and cause inconvenience to the neighboring facilities.
3) In cases when the already completed Facility is located nearby, there is a risk of subsidence, so muck shall not be piled on top of the Facility.

(4) Foundation Work

The contractor shall implement foundation work with sufficient consideration to the following items.
(1) Reservoir dead weight and surcharge
(2) Compacting of crushed stones in the foundation
(3) Curing period of foundation concrete
(4) Finishing height of foundation
(5) Finishing margin of foundation edge

(Commentary)
Prior to the foundation work, it is necessary to examine whether foundation work should be carried out in line with the initial plan, taking into consideration the status of spring water confirmed during excavation work and the ground conditions. It is also necessary to confirm the status of the foundation ground and whether it is possible to secure the required ground bearing capacity of the designed foundation when leveling work is completed. In cases when there is a confirmed possibility that the groundwater level may exceed the level of the reservoir bottom due to rains, or that there is soft ground containing humus, etc., under the foundation that threatens to cause uneven settlement, the contractor should consider changing the initial plan and building a reinforced concrete foundation.

(1) Reservoir dead weight and surcharge
One of the most important aspects of foundation work, in addition to ensuring the precision of the finishing surface, is to secure sufficient ground bearing capacity. In the case of large-scale facilities, it is possible that the quality of the ground differs in different parts of the excavation area, so it is necessary to consider measures to deal with this matter.

In cases when ground conditions at the time of excavation differ from the conditions when the design was formulated, the contractor should take necessary measures to deal with the matter, including replacement of materials selected in the initial plan with higher-quality materials.

(2) Compacting of crushed stones in the foundation
The contractor shall carry out thorough compacting of crushed stones in the foundation in order to secure an even finishing.

Crushed stones in the foundation

(3) Curing period of foundation concrete
The contractor shall secure sufficient curing period for t foundation concrete, and shall maintain the necessary temperature and humidity conditions adjusted to the type of concrete in order to ensure the prescribed hardness.
Below are reference values for each type of concrete.

Portland blast-furnace cement (B type)	at least 7 days
Ordinary Portland cement	at least 5 days
High-early-strength Portland cement	at least 3 days

(4) Finishing height of foundation
The finishing precision of the foundation has significant impact on the assembly process, so it is necessary to ensure an even finish.
As shown in above photo, the finishing height of the foundation shall be controlled by installing finishing stakes at a distance of 2-3m in the leveling. An example of foundation geometries is shown in Figure 3.4-3.

Height Control of Foundation

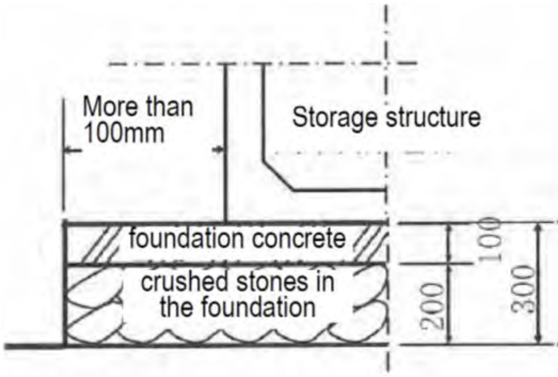


Figure 3.4-3 Example of Foundation Geometries

(5) Finishing margin of foundation edge
A distance of at least 100mm shall be secured between the foundation edge and the assembly edge of the storage structure as shown in Figure 3.4-3.

(5) Assembly Work Procedure

The reservoir assembly work shall comprise the following operations
(1) Placement of bottom sheets
(2) Assembly of storage structures
(3) Placement of side sheets
(4) Placement of top sheets
(5) Construction of auxiliary facilities

(Commentary)
The standard workflow of assembly operations is described in Figure 3.4-4.

Placement of bottom sheets
↓
Assembly of storage structures
↓
Placement of side sheets
↓
Placement of top sheets
↓
Construction of auxiliary facilities

Figure 3.4-4 Standard Workflow of Assembly Operations

(1) Placement of bottom sheets
Protection sheets and water impermeable sheets shall be placed as bottom sheets in storage facilities, and water permeable sheets shall be placed as bottom sheets in infiltration facilities. Examples of placement of bottom sheets at each type of facility are shown in Fig. 3.4-5. Photo 3.4-5 shows the status of placement of sheets in a storage facility.

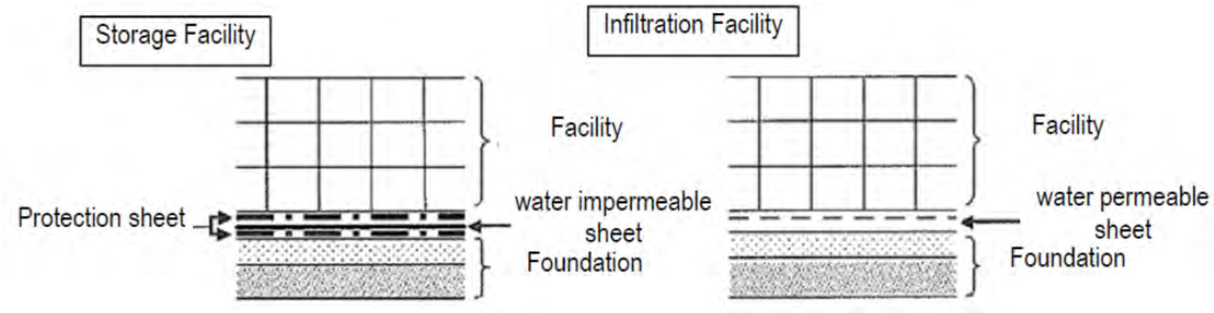


Figure 3.4-5 Example of Bottom Sheets Placement

Photo 3.4-5 Placement of bottom sheets **Photo 3.4-6 Placement of top sheets**

(2) Assembly of storage structures
The storage structures shall be assembled based on the design blueprint. Refer to "3.4.2(7)" regarding points of caution in assembly work.

(3) Placement of side sheets
Placement of side sheets shall be implemented in the same manner as placement of bottom sheets: protection sheets and water impermeable sheets shall be placed as side sheets in storage facilities, and water permeable sheets shall be placed as side sheets in infiltration facilities.

(4) Placement of top sheets
Water permeable sheets are often used as top sheets in storage facilities, but there are cases in which water impermeable sheets are placed instead with view of the local conditions. (See Photo 3.4-6).

(5) Construction of auxiliary facilities
Auxiliary facilities shall be constructed based on the design blueprint.
When the reservoir is a storage facility, in order to maintain its storage properties, placement of sheets in the joining sections of the reservoir and the auxiliary facilities shall be implemented in line with the following procedures.
1) Cover sheets shall be placed over the installation section of the auxiliary facility in order to prevent water seepage.
2) The sheets and the cover sheets shall be linked, and the auxiliary facility and the sheets shall be joined together.
3) The pipe shall be covered with water impermeable sheets and protection sheets.

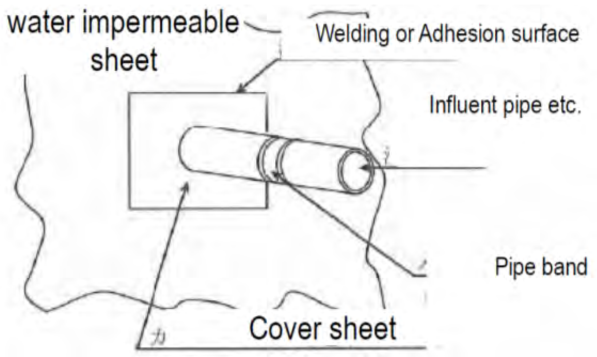


Figure 3.4-6 Sheets Placement at Joining Sections

(6) Assembly of Storage Structures

The contractor shall assemble storage structures with sufficient consideration to the specifics of each component, while paying particular attention to the following matters.
(1) Shock
(2) Storage methods
(3) Deciding of locations and placing
(4) Fitting together of storage structures
(5) Safety measures

(Commentary)
Storage structures have different specifics, depending on the manufacturer, and the methods for their assembly also differ, so it is necessary to use the assembly manuals and instructions for use of each storage structure in use and to bring them to the knowledge of the workers.

(1) Shock
Excessive shock may cause deformation or break of storage structures, so it is necessary to pay special care when unloading components from truck pallets at purchase, and prevent contact between components and other materials or dropping, etc., of components during construction work.
Usage of broken components is forbidden, and the contractor shall use replacements.

(2) Storage methods
In order to avoid degradation of plastic components caused by exposure to direct sunlight, it is necessary to shorten as much as possible the period between their purchase and their assembly. In cases when a long period between purchase and assembly is envisioned, the components shall be placed on a horizontal surface to avoid breakage and deformation, and covered with sheets to protect them from exposure to direct sunlight. (The materials shall not be exposed to direct sunlight for periods that exceed the period verified through the light stability promotion tests under the chemical durability evaluation methods described by manufacturer.)

The contractor shall exercise due care to avoid adherence of chemical agents and oil to the components, and if such agents or oil adhere to the components, shall immediately remove them with a cloth, etc. The contractor shall also keep the components away from fire, and shall pay special attention to avoid ignition caused by open flames or sparks during welding work, etc.

(3) Deciding of locations and placing
When assembling storage structures, the contractor shall measure the horizontal locations specified in the design documents, and shall mark them. In order to monitor the correct locations and confirm distortions or tilting during construction work, the contractor shall install in advance offset stakes, and shall place the storage structures horizontally. The construction work supervisor shall confirm the possible presence of broken or defective components prior to assembly work, and shall conduct

thorough guidance to ensure that workers do not make mistakes in the direction and placement of components when assembling them.

The larger the scale of the facility is, the greater the relation between the precision in placing the bottom level structures and the possibility for lifting or gaps in the components in the sections above later, so the contractor shall exercise special care in placing work.

(4) Fitting together of storage structures
The fitting together of storage structures has a significant impact on the strength and durability of the Facility, so the contractor shall implement it in a stable and precise manner, making sure that there are no left out structures or elements that are not inserted enough.

The joining sections should be checked for their soundness visually or by shaking them, from time to time.

(5) Safety measures
In assembly work, the contractor shall exercise due care to prevent walking accidents that involve dropping of materials or falls from the top of the reservoir, unstable areas, or bad visibility when transporting materials. In the case of tall facilities, in particular, the contractor shall exercise special care to prevent collapse of the reservoir edge and secure safe walking in the surrounding area.

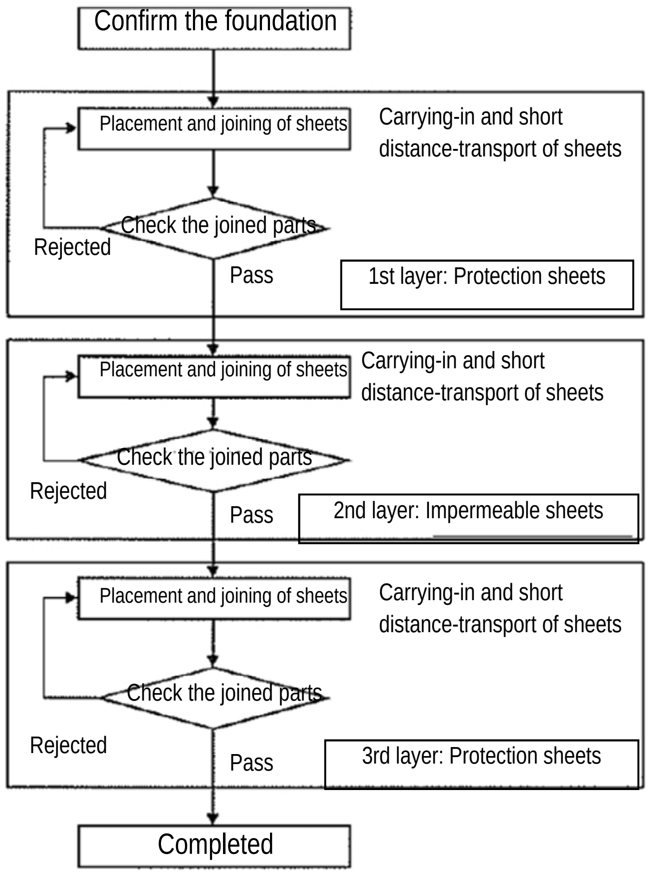
(7) Placement of Sheets

The following type of sheets shall be appropriately utilized with consideration of the purpose of the reservoir.
(1) Water impermeable sheets and protection sheets
(2) Water permeable sheets

(Commentary)
Sheets shall be placed by temporarily fixing them with adhesive tapes, etc.
In principle, operations for placement of sheets shall be carried out by specialized and skilled personnel.

(1) Water impermeable sheets and protection sheets
Water impermeable sheets are placed with the objective of securing reservoir properties. Their role is extremely important, and normally they are protected with protection sheets. The contractor shall exercise due care to ensure that the sheets are damage-free.

The procedure for placement of sheets in a three-layered structure (protection sheets + water impermeable sheets + protection sheets) is outlined in Fig. 3.4-7.



* Short distance-transport means hauling materials from the carrying-in site in the construction yard to the placement site

After the impermeable sheet placement is completed, place the protection sheets swiftly.

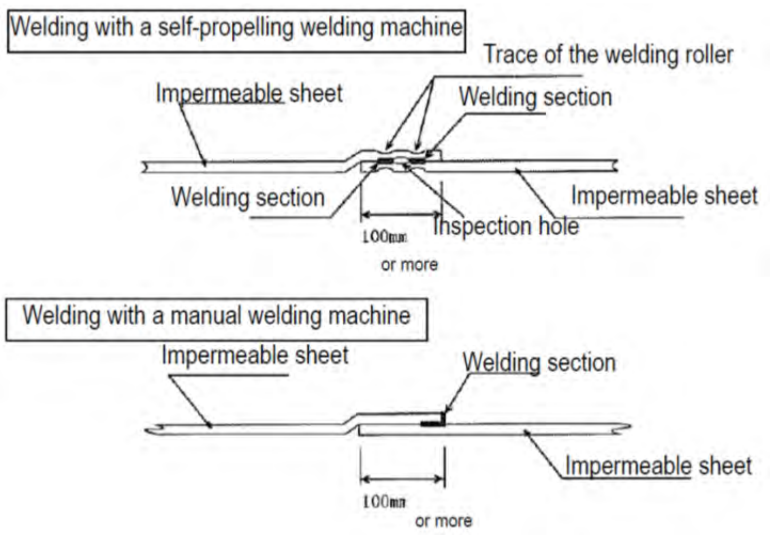
Figure 3.4-7 Installation Flow of the Sheets (In the case of 3-layer)

1) Placement of protection sheets and water impermeable sheets
The optimal configuration in placement of sheets is to keep the joining sections to the minimum, and in order to achieve it, protection sheets and water impermeable sheets shall be placed lengthwise, after ensuring that there are no reinforcing bars, stone fragments, or other sharp objects on the foundation surface. When placing sheets on a slope, the contractor shall exercise due care to avoid slippage or falling off of sheets.

The standard overlap width of protection sheets shall be over 100mm. If necessary, prior to shipping them to the construction site, water impermeable sheets may be processed in the factory to a shape that will match the profile and size of the surface on which the sheets will be placed. The overlapping length of joint sections must exceed 100mm when the sheets are welded together, 150mm when the sheets are joined together using adhesive tapes, and 200mm when the sheets are joined together using adhesive. Protection sheets and water impermeable sheets may also be placed on the bottom of the foundation section.

2) Temporary fixing of protection sheets and water impermeable sheets
In cases when there is a possibility that protection sheets or water impermeable sheets may be dispersed or displaced because of wind, etc., prior to their joining together, they will be temporarily fixed in place using sandbags, etc. Special care should be exercised in the case of sheets placed on a slope surface, in particular, to ensure that they do not slip down.

3) Joining of water impermeable sheets
There are two methods for joining sheets: joining by welding, and joining by adhesion.
(i) Joining by welding
The methods for joining sheets together by welding using self-propelling welding machines or manual welding machines are described in Figure 3.4-8.



A self-propelling welder is a type on rollers, capable of regulating heating temperature, operation speed and rolling pressure.
An inspection hole will be provided in the welded section, by injecting compressed air therein.

The manual welder is designed to be used to weld small sections not able to be welded by self-propelling welder.

Figure 3.4-8 Welding of Impermeable Sheets

(ii) Joining by adhesion
The methods for joining sheets together by adhesion using adhesive tapes or adhesive agents are described in Figure 3.4-9.

The crimping device uses a rotating roller to determine the optimal pressure bonding method and drying period based on the specifics of the adhesive tapes or adhesive agent, and applies a reinforcement tape at the joining edges in order to prevent turning-up of the water impermeable sheets. When joining sheets using adhesive agents, it is not possible to implement inspection through inspection holes. So butyl rubber-type agents with low gas permeability, good vibration reduction properties, durability, resistance to chemical agents and light stability should be selected as the standard adhesive agents.

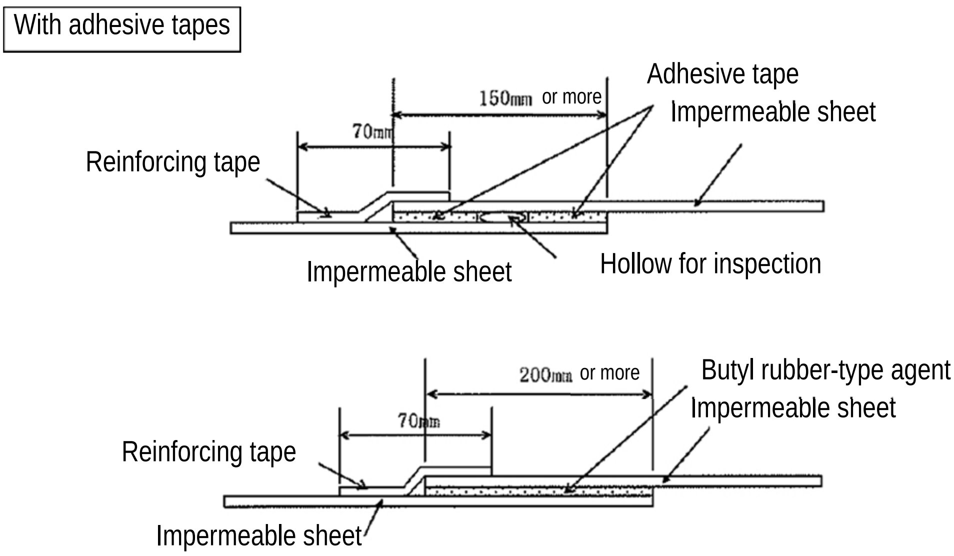


Figure 3.4-9 Welding of Impermeable Sheets

4) Inspection of joining areas
In principle, inspection of joining areas of water impermeable sheets for both sheets joined by welding and sheets joined by adhesion, is implemented through visual observation and pulling.

In the case of sheets joined by adhesion, inspection is carried out using a sharp tool, such as a screwdriver, which is inserted in an opening in the joining surface and is used to poke at the adhered sections to check whether they have not separated (see in Figure 3.4-10).

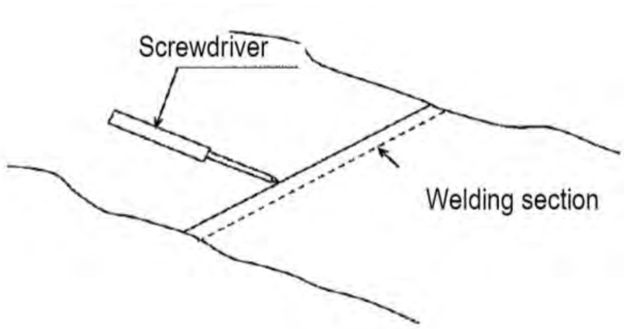


Figure 3.4-10 Inspection Example of a Joining Section 1(using a screwdriver)

The following two methods can also be applied as necessary in order to inspect joining areas.

(i) Pressure inspection
In cases when sheets have been joined using a self-propelling welding machine or adhesive tapes, pressure is applied on the hollow part for inspection purposes (see Figure 3.4-8 and Figure 3.4-9), and it is checked whether there are no leaks of pressure. This method is described in Figure 3.4-11.

The procedure is as follows. A nozzle is inserted in the inspection area of the hollow part between the joining section of the sheets (a hollow string may be installed in advance between the tapes to form a hollow area). Next, the opening for inspection purposes is sealed, and pressure is applied by feeding in compressed air. Pressure in the range of 0.05 ~ 0.15 MPa is maintained for 30 seconds, and if no leaks are confirmed and the drop in the pressure is within 20 % of the designated pressure, the joining area passes the inspection.

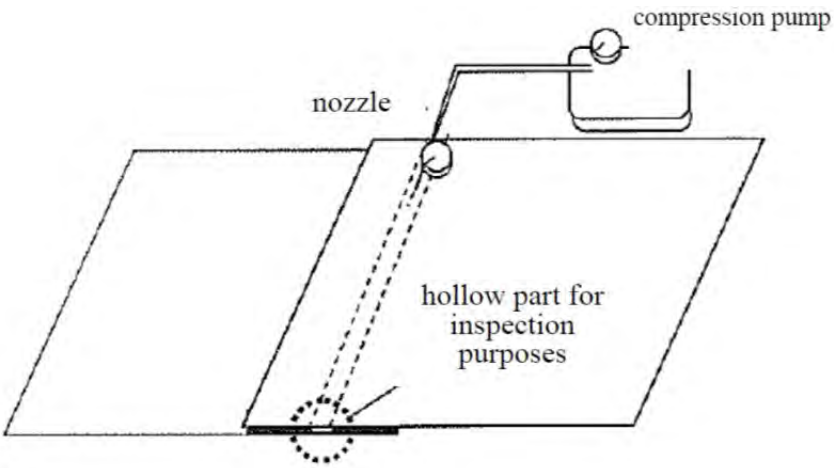


Figure 3.4-11 Inspection Example of a Joining Section 2 (pressure inspection)

(ii) Negative pressure inspection
When three layers of sheets are joined, when it is not possible to form a hollow part for inspection, or when pressure inspection cannot be implemented, negative pressure inspection is carried out using the method outlined in Figure 3.4-12.

The procedure is as follows. Soapy water is spread on the inspection area. Next, an opening is made on one side only, a transparent container-shaped inspection tool with a packing sealing the circumference of the opening is applied onto the inspection area and the interior of the container is decompressed using a decompression pump. Negative pressure of about -6.7 kPa is maintained for about 10 seconds, while observing for presence/absence of blisters, and if bubbles do not appear, the joining area passes the inspection.

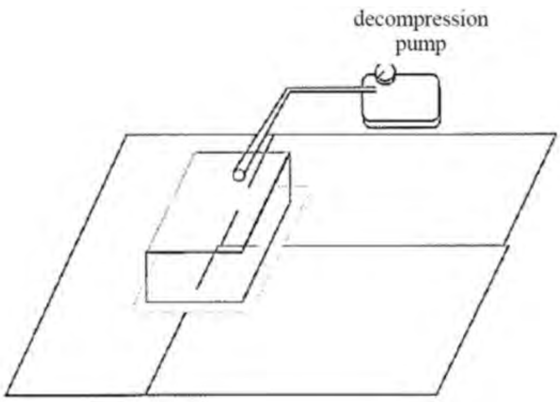


Figure 3.4-12 Inspection Example of a Joining Section 3 (Negative pressure inspection)

5) Joining with auxiliary facilities
The way of joining auxiliary facilities and reservoirs is described in Figure 3.4-13.

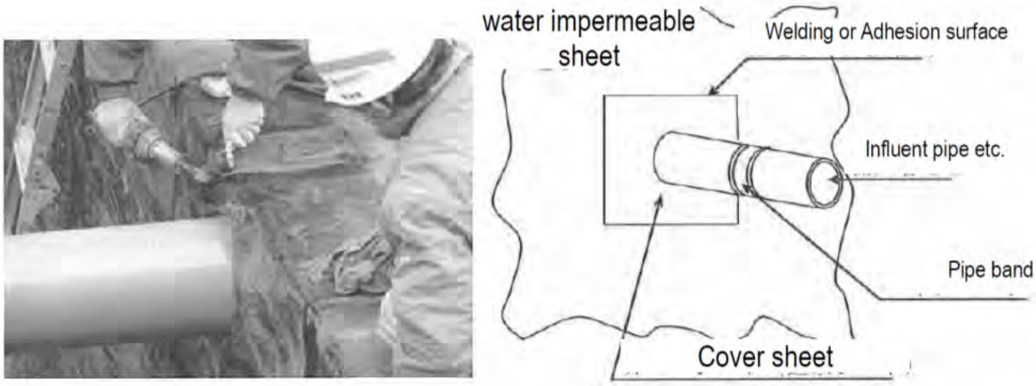
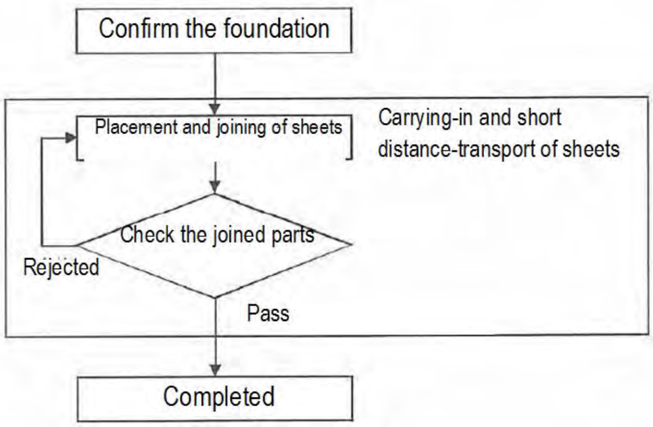


Figure 3.4-13 Sheet Placement at Joining Sections

Joining of sheets is conducted through thermal welding, so all earth, impurities, and moisture, etc., attached to the joining surfaces should be removed. It is recommended to secure an onsite joining breadth of at least 20mm and an overlap width of at least 30mm. In most cases, joining work is implemented with manual welding devices, using the hot air welding method.

When the reservoir is a storage facility, measures should be taken to prevent the appearance of gaps between the facility and the connection pipes by using cover sheets in the joining areas to achieve full integration in order to maintain the storage functions of the facility.

(2) Water permeable sheets
Non-woven materials are usually used for making water permeable sheets, but since they are easily damaged, the contractor shall exercise due care to not break the bubble wrap when purchasing the sheets, and to not damage them with tools, etc., when unwrapping them. The procedure for placement of water permeable sheets is described in Figure 3.4-14.



* Short distance-transport means hauling materials from the carrying-in site in the construction yard to the placement site

Figure 3.4-14 Work Flow of Water permeable sheets

1) Placement of water permeable sheets
The optimal configuration in placement of sheets is to keep the joining sections to the minimum, and in order to achieve it, water permeable sheets shall be placed lengthwise, after ensuring that there are no reinforcing bars, stone fragments, or other sharp objects on the foundation surface. The standard overlapping width when placing water permeable sheets shall be about 100mm. When placing sheets on a slope, the contractor shall exercise due care to avoid slippage or falling off of sheets.

2) Temporary fixing of water permeable sheets
In cases when there is a possibility that protection sheets or water impermeable sheets may be dispersed or displaced because of wind, etc., prior to their joining together, they will be temporarily

fixed in place using sandbags, etc. Special care should be exercised in the case of sheets placed on a slope surface, in particular, to ensure that they do not slip down.

3) Joining of water permeable sheets
The overlapping sections of water permeable sheets can be joined by adhesion (using adhesive tapes or adhesive agents), or by welding.

(8) Backfilling Work

Backfilling work is implemented using good-quality soil in order to achieve sufficient compacting. It is also necessary to utilize appropriate backfilling materials and equipment taking into consideration the purpose of the Facility. (1) Backfilling materials (2) Backfilling equipment

(Commentary)
The materials used in backfilling work differ depending on the purpose of the Facility: whether it will be used as a storage facility or an infiltration facility. Also, due care should be exercised when selecting backfilling procedures and equipment to ensure that they match the scale of the Facility. The contractor shall also give sufficient consideration to measures to prevent damage of sheets during backfilling work.

(1) Backfilling materials
For storage facilities, soil displaced at the construction site or good quality sandy soil are used as backfilling materials. For infiltration facilities, in principle good quality sandy soil is used as backfilling material on the infiltration surface. It is necessary, however, to pay special attention to the possibility of liquefaction of backfilling materials in the event of an earthquake, etc.

(2) Backfilling equipment
The devices listed below shall be used in operations for backfilling and compacting.

1) Backhoes
2) Shovel dozers
3) Bulldozers

(9) Compacting Work

Compacting work is implemented using appropriate methods by dividing the surrounding area in equal layers with a determined thickness

(Commentary)
Compacting work is implemented by spreading and leveling each layer. Compact it using appropriate equipment. Rolling compaction is carried out using the devices listed below. Concentration of compacting work in one area should be avoided as it may damage the storage structure, and compacting should be carried out evenly across the entire surface.

1) Rammers
2) Plate compactors
3) Tampering tool (*tako*)
4) Vibration rollers
5) Compact bulldozers

In principle, the thickness of each layer in backfilling work shall not exceed 30cm, while in the case of parking lots and other subgrade areas it shall not exceed 20cm.

3.4.3 Cautions on the Construction

(1) Handling of Muck

The muck shall be handled or disposed of in an appropriate manner, considering the characteristics, the amount, etc., of the muck. (1) Case of using the muck as backfilling soil (2) Case of treating the excavation muck

(Commentary)
Excavation muck, which is the "soil generated in the process of construction", can be utilized as construction material, taking advantage of its inherent properties according to the category in classification.

Excavation muck shall be used as far as possible for the use of backfilling and as material for related civil engineering works. When conveying it out of the site, it shall be disposed of appropriately by carrying it to the surplus soil-disposal site specified in the construction plan, with a prior agreement with the competent section of the municipality.

With regard to the "soil generated in the process of construction" and "construction sludge" which do not conform to the requirements imposed by the muck-receiving organization (surplus soil-disposal site), they shall be disposed of appropriately as industrial waste.

(1) Case of using the muck as backfilling soil
When using construction muck as backfilling soil, in some cases, it is stored temporarily at a place out of the excavation site. When it is deposited temporally behind an earth retaining wall, the said wall may suffer a design-exceeding lateral pressure, constituting causes of deformation and ground instability. In the case of a temporal storage, the designated place for temporal storage of muck and the height of the muck pile should be strictly observed. Stones and concrete masses, mingling with the excavation muck, should be removed, and an effort should be made not to allow a concentrated load to work nor to exert adverse effect on the reservoir.

(2) Case of treating the excavation muck
Excavation muck should be promptly conveyed to a designated place for treatment, according to the treatment plan. When establishing the treatment plan, recycling the excavation muck should be considered. The principal items to be considered in the treatment plan of excavation muck are as shown below;
1) Determination of a treatment method and a site of disposing of the muck
2) Determination of a muck-carrying out and transportation method and a route of transportation as well as the operation plan of transportation vehicles.

(2) Cautions on the Installment of Sheets

When laying sheets, pay attention to the following; (1) Check of the substrate (2) Carrying-in and storage of sheets (3) Weather conditions (4) Backfilling work

(Commentary)
In order to keep the Facility in good function, when installing sheets, confirm the status of the substrate, and pay attention to the carrying-in and storage of sheets, as well as to metrological conditions and back filling works.

At the time of installing impermeable sheets, pay sufficient attention to the joining of sheets in order not to allow rainwater leakage and so that the reservoir may not lose water-retaining function due to groundwater intrusion. Therefore, have a person(s) who is familiar with sheet installation with appropriate tools engaged in joining work.

(1) Check of the substrate
Sheets are frequently deteriorated due to deficiency of the substrate. Absolutely avoid installing sheets, with the condition that there remain projections like stones on the substrate, and with the likelihood of an uneven settlement.

Presence of in-situ springs and intrusion of rainwater may cause a significantly adverse effect on the quality control of sheets, and in such cases, it is necessary to implement their drainage.
The contractor shall make it a rule, prior to construction to confirm the conditions of a substrate in the presence of the owner and after its agreement, to place sheets.

(2) Carrying-in and storage of sheets
Sheets should be carried in and put in storage as instructed below;

(i) Use a designated route to carry in project materials.
(ii) Pay sufficient attention to the materials during loading, unloading and transportation so as not to damage them, and protect them as required.
(iii) After opening the package, deliberately handle the materials manually, and with the likelihood that the materials may be damaged when being hit against the corners of a building, provide a wide free space at the surroundings of their temporal storage place.
(iv) In the case of lifting a sheet(s) by a heavy machine, use a hanging tool made of plastics such as nylon slings, not to damage the sheet.
(v) In the proximity of a construction site, provide a storage yard to keep the materials from direct sun light, rain, wind, etc., and especially as a shelter from rain, protect them with a protection sheet, etc.

(3) Weather conditions
If under the weather conditions below, immediately discontinue the operations.

(i) Strong winds (under which the sheet may come off the ground and fly off).
(ii) Extremely low temperatures which may hamper smooth construction (at the time of a difficult temperature control)
(iii) Weather conditions of rainfall and snowfall which make difficult hot welding and joining of the joint.
(iv) Other cases where it may be judged difficult to continue the operation due to unexpected events.
(v) Torrential rain which makes the reservoir float on the water (this event may occur in a state where the reservoir is installed under grounds and not yet backfilled.

(4) Backfilling work
When backfilling, take measures to prevent displacement of sheets. And confirm the sections of sheets on the overlapping for not rolling up.

(3) Cautions on the Construction of Auxiliary Facilities

The contractor shall construct the following auxiliary facilities in order that the reservoir may develop its function at a desired level by paying attention to their installation height and the water-proofing of the joints.
(1) Influent chamber (grit chamber)
(2) Drainage chamber
(3) Influent connection pipe and effluent connection pipe
(4) Inspection hole and exhaust port
(5) Overflow pipe
(6) Manhole
(7) Orifice

(Commentary)
Since in the case of an auxiliary facility connecting with the reservoir, connection is made by making it pass through the sheet, particular attention is required to how to establish connection at the coupling section. In the case of constituting a monobloc of the reservoir and its auxiliary facility, the contractor shall endeavor so that they may develop their function fully, by packing adequately the Facility with impermeable sheet, protection sheet or permeable sheet.

(1) Influent chamber (grit chamber)
Constructing the facility of influent chamber shall be made confirming the positions and heights specified in the design documents.

(2) Drainage chamber
Constructing the facility of drainage chamber shall be made confirming the positions and heights specified in the design documents.

(3) Influent connection pipe and effluent connection pipe
At the positions of providing an influent connection pipe and effluent connection pipe, their connection holes should be provided beforehand at the heights which are confirmed by the design documents. The influent and effluent connection pipes should be installed at their connection hole, and to the surrounding of the hole, caulking compound is applied for finish and water cut-off.

(4) Inspection hole and exhaust port
They should be provided by confirming to the heights and positions which are specified in the design documents.

(5) Overflow pipe
For the overflow pipe, its installation hole should be provided beforehand by confirming the height specified by the design documents. The overflow pipe shall be introduced into the orifice provided, and the surroundings of the pipe port at the connection section should be finished with caulking, etc for water shielding.

(6) Manhole
The manhole, as an inspection hole, is provided for the influent and drainage facilities. The foundation of crushed stone should be compacted sufficiently by the use of an appropriate compactor in order to prevent the manhole shaft from subsiding.

Before installing the manhole shaft, the contractor shall check it for the position and height referring to the design documents. When installing the manhole shaft, it should be lifted up by the use of an appropriate lifting tool.

(7) Orifice

When orifices are constructed at site, make sure their height and size as specified in the design documents. When manhole shaft is installed with an orifice, take care of the instructions given in (6).

(4) Cautions on Backfilling Work

The backfilling work should be made paying attention to the items below.
(1) Offset loads and impact working when backfilling in the surroundings
(2) Loads working when backfilling on the top
(3) Temporary rising of the water level
(4) Timing for backfilling
(5) Backfilling of the places where earth retaining supports were planted
(6) The height of the embankment on the Facility
(7) Confirmation of adverse changes in the status when backfilling

(Commentary)
Backfilling will be made as early as possible after the complete assemblage of the reservoir. In the order of works, the soil, as serving as weight, is placed on the ceiling, in a good balance, to keep the reservoir from displacing due to lateral earth pressures as well as to prevent displacement of sheets. The surroundings of the reservoir shall be backfilled uniformly from the four sides, not to allow lateral loads to work to the sides of the reservoir. After that, the backfilling on the top of the reservoir will be made to a specified height of earth covering.

(1) Offset loads and impacts working when backfilling in the surroundings
The backfilling on the sides of the reservoir will be made into layers of about 30 centimeters in thickness each, for the prevention of deformation and deterioration of the reservoir under offset loads. Backfilling should be made as evenly as possible from the four sides and be sufficiently compacted, so as to prevent offset loads of earth pressure which may lead collapse and deformation of the reservoir.

For the necessity of keeping the sheets from damage and the storage structure from deformation and breakage due to collisions of stones which exist in the backfilling soil, dumping the backfilling soil should be made deliberately.

In a case there is probability that the facility may collapse and displace under lateral soil pressures, a concern resulting from the scale and form of the Facility, the contractor should adopt a solution, as the first step, of temporarily placing a load of backfilling soil on the top of the reservoir which does not exceed a tolerable loading stress.

(2) Loads working when backfilling on the top
Backfilling soil on the top of the reservoir will also be placed into layers of about 30 centimeters in thickness. Considering that the load acts directly to the storage structure, the work should be implemented deliberately not to induce breakage and deformation of the facility.

When a heavy machine is used on the top surface of the storage structure covered with an impermeable sheet, a covering layer of soil 50 centimeters thick is formed. If the heavy machine is with caterpillar, it shall be operated deliberately, paying the closest attention to steering.

(3) Temporary rising of the water level
This manual specifies the facility should be built above the potential upper limit of groundwater level. In heavy rainfall, the water level may rise temporarily higher than expected, it is apprehended that the reservoir would float by force of buoyancy. In the case above, the following should be kept in mind.

1) Sumping
During construction, sumps should be built to collect the water for pumping drainage.

2) Steps for backfilling
In backfilling, giving antecedence to the surroundings of the reservoir leads a danger that it may displace and float. To avoid this concern, the space on the top of the reservoir should be backfilled at the same time.

3) Backfilling material
The backfilling material should be of good quality, and subject to sufficient compaction.

4) Height of backfilling
The height of the completed backfilling should be slightly higher than the height of the surrounding ground, and finished with minute attention not to produce hollows and puddles.

5) Measure to reduce the buoyancy
After the reservoir is put in service, the water from rainfalls enters the reservoir, making it possible to keep a good balance. However, during the construction, the contractor is recommended to keep the water in the reservoir to reduce the buoyancy.

(4) Timing for backfilling
The reservoir, because of being light in weight, is likely to float due to buoyancy, when the bottom and the surroundings of the dug hole are flooded at the time of rainfall. Considering this, it is desirable to backfill the soil as early as possible after the assemblage of the reservoir.

(5) Backfilling of the places where earth retaining supports were planted
The voids which are formed when removing the earth retaining stakes shall be compacted with the sand of good quality, with watering compaction. In the case of a place involving the voids very likely to induce land subsidence, it should be backfilled with backfilling material such as mortar.

(6) Height of the overburden on the Facility
When backfilling, the overburden on the Facility should not exceed the design height, In the case the overburden is made higher than the design height, it should be limited in a range of not exceeding the tolerable stress when loading.

(7) Confirmation of adverse changes in the status when backfilling
As past examples, there were cases where adverse alterations on the storage structure were experienced and their cause was assumed to be an offset earth pressure during backfilling. Therefore, when backfilling, the contractor is recommended to inspect from time to time the storage structure to confirm there is no adverse alterations.

(5) Cautions When Backfilling at the Place of Auxiliary Facilities

When backfilling at the places of auxiliary facilities, particular measure should be implemented for each of the locations below.
(1) Influent connection pipe and effluent connection pipe
(2) Inspection hole and exhaust port
(3) Influent chamber and drainage chamber

(Commentary)
Backfilling at the places of auxiliary facilities should be made, in principle, manually. In particular, at the connecting sections of a small space should be compacted carefully with a small tampering tool (*tako*).

(1) Influent connection pipe and effluent connection pipe
For the influent and effluent connection pipes, the following items should be taken care of;

1) Backfilling material and timing for backfilling
For the backfilling, the material of good quality shall be used and sufficiently compacted, and prior to this operation, it is confirmed that the mortar and protection concrete at the connecting sections develop their strength to a sufficient degree.

2) Protection with a protection cap
When installing the influent connection pipe and effluent connection pipe after pulling-out of the earth retaining material, the contractor is in the need of backfilling the voids produced after the removal of the said material, the ends of the connection pipe should be protected with the caps placed. In order to make the positions of the pipes discernible, they should be marked with a sign.

(2) Inspection hole and exhaust port
At the surroundings of the inspection hole shaft and the exhaust port shaft projecting vertically from the facility, an uneven subsidence is prone to produce heaves and irregularities on the pavement surface; to avoid these, for backfilling, the material of good quality should be used.
The soil should be spread adequately in layers and compacted.

(3) Influent chamber and drainage chamber
At the surroundings of the influent and drainage chambers, an uneven subsidence is prone to produce heaves and irregularities on the pavement surface; to avoid these, for backfilling, the material of good quality should be used and sufficiently compacted.

(6) Equipment to Be Used for Backfilling Work and Compaction Work

Take care of the following items about the backfilling work and compaction work.
(1) Equipment to be used over the reservoir
(2) Compaction machinery

(Commentary)
The machine, when being put on the top of the Facility, shall in principle be the one on caterpillar. When using a machine on wheels, the ground shall be protected with steel boards, etc. In the case of backfilling on the top of the facility, select a machine paying attention to an admissible loading stress on the Facility.

(1) Equipment to be used over the reservoir
It is prohibited to use a construction machine producing a larger loading stress than the maximum tolerable load on the storage structure, when the said machine is operated thereon.

In the likelihood of exceeding the tolerable stress on the storage structure, in cases of using a vehicle such as dump truck or a crane, because of the available space being limited, the contractor should have a discussion with the Owner to take appropriate measures considering the tolerable loading stress on the storage structure.

(2) Compaction machinery
As compaction machinery, the contractor is recommended to use a plate compactor and rammer, paying attention to their operation in order that the sheets may not be broken by contacting the machines. Since when backfilling on the top of the storage structure, the sheets cannot be checked visually, the correct placement of the sheets should be confirmed adequately at initial laying of soil.

(7) Check Points to the Use of Heavy Machines

As for heavy machines to be used at the time of assembling the storage structure, they should be operated in safety, and according to the law and regulations applied.

(Commentary)
When using a heavy machine like a crane, the contractor should adhere to the safety rules and Labor Safety Rules, paying attention to the safety during work.

3.4.4 Construction Management

(1) Safety Management

For construction works, the contractor shall establish a plan for measures concerning the following safety management items, and formulate a safety system. (1) Implementation of surveillance and patrols (2) Formulation of accident prevention measures (3) Construction of a disaster prevention system

(Commentary)
The contractor is recommended to prevent public disasters and labor disasters, and to implement an adequate safety management for the purpose of securing safety in the work.

(1) Implementation of surveillance and patrols
At the time of implementing construction works, monitors and guides should be placed in an appropriate manner according to the conditions of the site and the work method. In addition, a site manager should be stationed at the site to monitor through communication the inside of the site and its surroundings, and another manager for patrol/monitoring.

(2) Formulation of accident prevention measures
Before starting the work, all working members are requested to participate in the risk-predicting activities, etc., which consist in identifying risk items and formulating measures. In particular, as a measure against localized torrential rains, the contractor should secure required weather information and make effort for safety management on rainfalls.

(3) Construction of a disaster prevention system
In order that works are performed safely, and that labor disasters and public disasters are prevented beforehand, related law and regulations should be strictly conformed to, with establishment of a safety management system including appropriate development of the work environment of the construction site. For workers, safety education and health management are organized, and prevention of labor disasters and public disasters as well as hygienic management is put in execution. Along with the establishment of a communication system for the cases of disaster and accident, as well as of labor disaster, it is necessary to formulate a communication diagram.

(2) Process Management

For the work, the contractor should implement appropriate process management at the timings below; (1) Before starting the work (2) During the work

(Commentary)
The contractor should grasp work progress all the time, with an effort to proceed with the work as per process schedule. However, in cases where the process involves changes, and that their content is very important, as well as with regard to the work items the schedule of which is predetermined, the contractor should take appropriate solutions, holding in advance a discussion with the owner.

(1) Before starting the work
According to the process management plan, the contractor should provide basic principles such as

order of construction. In the event there are changes in the scheduled process, resulting from prior reviewing of the plan, the contractor and the Owner should have a discussion to take appropriate steps.

(2) During the work
During the work, the contractor should conduct comparison and review between the plan and the actual performance, from time to time. When a significant divergence is found between them, the contractor should take appropriate correction steps.

(3) Quality Control

Quality control at the time of receiving components should be conducted for the following items;
(1) Quality of pre-cast components
(2) Geometry and sizes
(3) Appearance
(4) Test

(Commentary)
At the time of construction, the contractor should check the components of the Facility for their conformity to the requirements in the "Design" of this manual.

(1) Quality of pre-cast components
Check the quality of pre-cast components referring to the test result sheets and mill sheets.

The contractor should prepare and keep, under the responsibility of the contractor the documentary materials certifying the quality of pre-cast components to be used for the work. On request for their submission by the Owner, the contractor should present them without delay.

(2) Geometry and sizes
The contractor should check the geometry and sizes of the component that they are in a tolerable range specified in 3.3.7(8).

(3) Appearance
The appearance of the component should be free of defects, cracks and missing parts, etc. which may exert adverse effect. The impermeable sheet should be free from defects and breaks that may exert adverse effect on its use. During the process of unloading, the components should be checked for noticeable breaks and damages.

(4) Test
Confirming the strength of components, etc. as a quality test item can be omitted when the shop manufacture management test data is available. With a discussion between the parties concerned, the contractor may beforehand take an option of visiting the manufacturer to confirm the quality of components.

(4) As-built Management

The as-built management after the completion of assemblage should be implemented for the following items;
(1) Planned storage volume
(2) Dimensions (height, width and depth)
(3) Installation position (coordinations)
(4) Installation altitude (altitude)

(Commentary)
The storage structure, since being made from plastics, may suffer dimensional changes due to

difference in temperature, resulting from the properties of the material. There may be changes in measured sizes between the summer and the winter.

Therefore, pay attention to the temperatures at the time of taking measurements. With regard to the as-built management, the management criteria, including objects of management, criteria of measurement, management methods, etc., should be determined beforehand through a discussion between the contractor and the Owner.

(1) Planned storage volume
Check the as-built performance of the work whether it satisfies the requirement for planned storage volume which is specified in the design documents. Based upon the dimensions of the reservoir, calculate the storage volume and record the results.

(2) Dimensions (height, width and depth)
The as-built status of the Facility should be checked for whether it satisfies the specified management criteria. Measure the height, width and depth to record their results.

(3) Installation position (coordinates)
The position of the Facility should be checked for whether it satisfies the management criteria, to record the result.

(4) Installation altitude (altitude)
The altitude at which the Facility is installed should be checked for whether it satisfies the management criteria, and the results of measurement should be recorded. The altitudes shown below shall be measured as the essentials;

- (i) Standard heights of the reservoir (bottom height, top height)
- (ii) Planned influent height (height of influent pipe bottom)
- (iii) Planned drainage height (height of drainage pipe bottom)

(5) Records for Construction Works

Construction work records should be taken for the following items for filing and storage.
(1) Completion plans
(2) Daily reports
(3) Photos recording working operations
(4) Records of as-built management
(5) Other items provided for in particular specifications

(Commentary)
Records of construction works serving as completion plans, after the arrangement methods such as recording manners and formats are confirmed, shall be grouped from time to time, and placed in order at the predetermined custody.

(1) Completion plans
Completion plans should be prepared according to the criteria in the specification In the designs prepared at the design stage, modifications, if any, should be input schematically in a manner to reflecting actual structures, and they are filed in order and storage as records.

(2) Daily reports
Daily reports describing work operations should be kept as routine duties, recording kinds of works, work content, instruction items and inspection items, and other topics of meeting in the form of a file for storage.

(3) Photos recording working operations

The photos reporting work operations are to serve not only as record of construction progress at each stage of construction but also, after the completion of the project, as a documentary material which demonstrates the as-built status of portions not confirmable from outside. They should be taken adequately to meet their purpose, and as a construction work record, should be filed and managed for storage,

(4) Records of as-built management
They are filed in order for storage, especially as a material recording size, installation positions, installation heights of as-built status after the completion of assemblage.

(5) Other items provided for in particular specifications
With regard to the items provided in the particular specification for each work site, they should, as record, be filed for storage.

3.5 Maintenance

3.5.1 Basic Policy

(1) Purpose and Method

Based on a thorough understanding of the functions of the Facility, appropriate maintenance shall be conducted to preserve the functions.

(Commentary)
The purpose of maintenance is to preserve the functions of reservoir with appropriate means and frequency based on a thorough understanding of its functions. Failure to appropriately operate and maintain the Facility may cause sediment deposition in the Facility or degradation of the infiltration function due to clogging, which may lead to failure to fulfill the expected purpose of the Facility.

Matters to be taken into consideration in maintenance include:
(i) Sustainment of the storage and infiltration capacity
(ii) Maintenance of the storage infiltration facility
(iii) Economical maintenance
(iv) Promotion of and enlightenment on the Facility through maintenance

Establishment of appropriate management specifics and system in relation to maintenance in view of the above is important.

The method of maintenance may vary depending on the conditions of the normal and flood times and maintenance must be conducted based on the work plan capable of dealing with such conditions.

The standard specifics of maintenance shall be as listed below.
1) Inspection
2) Maintenance
3) Preparation and storing of the Facility Register
4) Storing of maintenance records
5) Disaster and accident measures

In the infiltration facility, in particular, the infiltration function may be degraded by clogging to cause the reservoir to be permanently filled with water or inundated to overflow. When the facility has an overflow pipe connected, it is difficult to judge the degree of functional degradation by appearance. If such a condition is left unattended, attempts to restore the function may not succeed. To avoid such a situation, maintenance of the infiltration facility shall include efforts to prevent decrease of the infiltration capacity caused by clogging and to stably fulfill the function by adequately understanding the structural type of the facility and land use and topography of the installation location.

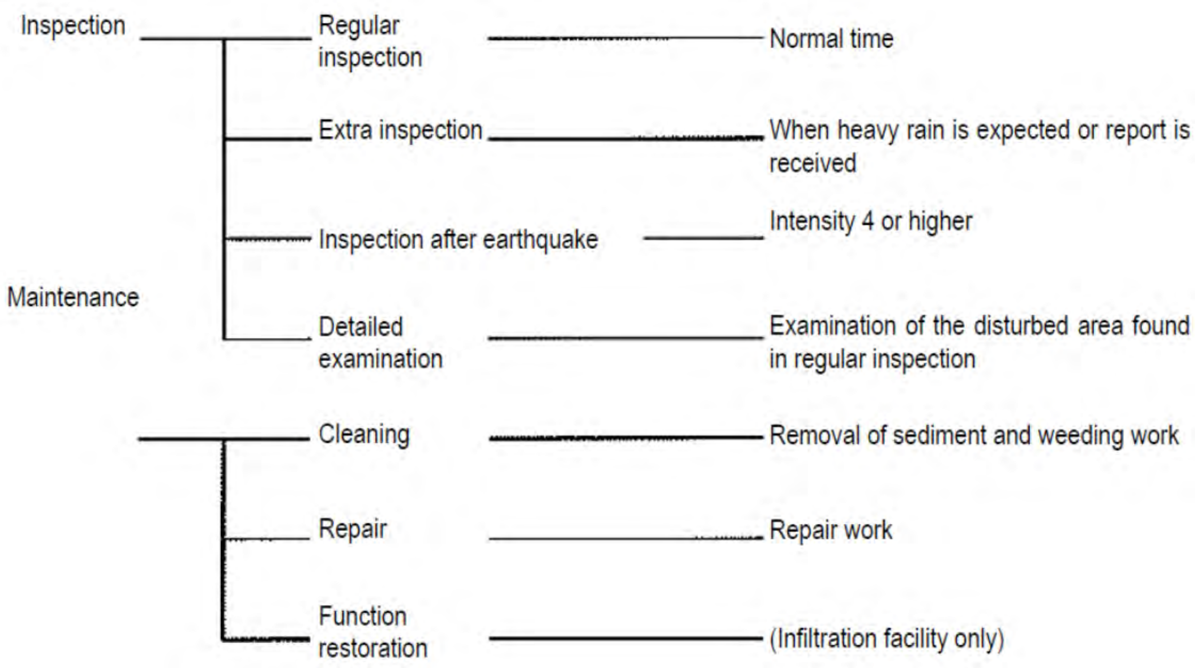


Figure 3.5-1 Maintenance of the Facility

The designated capacity can be restored by such means as carrying the deposited sediment out. In the infiltration facility, function restoration should preferably be confirmed. As a method of confirmation of the infiltration function, a constant or falling head permeability test may be conducted.

(2) Safety Management

Consideration shall be given to safety in implementing maintenance.

(Commentary)
When a worker enters the reservoir for the purpose of maintenance (such as inspection, cleaning and repair) of the Facility, adequate attention shall be paid to prevent fall accident and protective gears such as a safety belt and lifeline shall be worn.

The Facility is made of plastic and adequate attention shall be paid to heat and fire. Entry into the reservoir may subject the worker to oxygen deficiency, hazardous gases such as hydrogen sulfide and carbon monoxide or explosive gases such as gasoline. Before entry, adequate measurement of their concentrations, etc. shall be made by using instruments and forced ventilation shall be carried out as required. Before conducting works such as cleaning and inspection in the reservoir, weather information shall be obtained as a measure against a localized downpour. In addition, it is important to establish in advance a contact system and emergency evacuation procedures.

3.5.2 Management Specifics

(1) Management Items

Items to be managed shall be appropriately determined based on the type, scale, auxiliary facilities, etc. of the Facility.

(Commentary)
The Facility is intended for mitigating the maximum rainwater runoff in a flood time and may be of a

variety of types depending on the type of the storage and infiltration facilities, facility scale and type of the influent, drainage, and maintenance facilities. For this reason, appropriate management items shall be determined according to the facility. Visual inspection is common and the standard items and methods of maintenance shall be as shown in Table 3.5-1.

Table 3.5-1 Items and Methods of Maintenance

Inspection point		Management item	Method of maintenance
Influent facility	Influent chamber (grit chamber) channel	Sediment	Removal by suction Digging out
	Screen (orifice filter)	Impurity	Removal, cleaning
	Influent pipe, influent connection pipe, Channel	Damage, clogging, Sediment	Removal and cleaning for clogging Repair or replacement for damage Digging out
Reservoir	Inspection hole	Damage, sediment	Repair or replacement for damage Removal by suction for sediment
	Sand trap	Sediment	Removal by high-pressure cleaning
Drainage facility	Drainage chamber	Sediment	Removal by suction
	Screen	Impurity	Removal, cleaning
	Orifice Overflow pipe Effluent connection pipe, discharge pipe	Clogging, damage	Removal and cleaning for clogging Repair or replacement for damage
	Drainage pump	Functional degradation, deterioration, damage, clogging	Removal and cleaning for clogging Repair or replacement for functional degradation, deterioration and damage

(2) Inspection

Inspection of the Facility shall be of the following types.
(1) Regular inspection
(2) Extra inspection
(3) Inspection after earthquake
(4) Detailed examination

(Commentary)
The Facility may suffer degradation of its original functions if sediment brought in together with influent water is accumulated, material deterioration or shape change due to chemical and/or physical effect over time or deformation caused by earthquake.

Inspection is intended for promptly detecting these disturbances and deciding whether or not cleaning and repair are necessary. Inspection of the Facility includes regular inspection, extra inspection and emergency inspection after the occurrence of an earthquake (after an earthquake of intensity 4 or higher*).

The maintenance plan shall be made with due consideration given to the characteristics of the Facility. Inspection shall be conducted systematically and safely at appropriate times and under a proper management system and the results of the inspection should preferably be recorded.

(1) Regular inspection
1) Regular inspection shall be conducted at regular intervals such as three months, six months and one year and during the rainy season at regular intervals one month or two weeks.

2) Inspection points and points to be checked

The inspection points and points to be checked in normal times shall be as shown in Table 3.5-2.

Table 3.5-2 Inspection Points and Points to Be Checked in Normal Times

Inspection point	Check for…
Influent facility	Abnormality in the mounting pipes, water leakage, sediment condition in the grit chamber and channel, screen clogging, dirt in the influent opening, etc.
Reservoir	Sediment condition
Drainage facility	Abnormality in the structure, pump condition, sediment condition, screen clogging, etc.
Aboveground part	Depression or swelling

3) Inspection specifics

The inspection specifics in normal times shall be as shown in Table 3.5-3. If any damage to the Facility or functional degradation is found as a result of inspection, its cause must be identified and necessary measures such as repair and cleaning taken promptly to restore the function.

Table 3.5-3 Inspection Specifics

Type / Specific	Functional inspection	Safety inspection
Inspection item	1. Condition of accumulation of sediment, dirt and fallen leaves 2. Screen clogging condition 3. Condition of drainage of the Facility (check on the inspection hole and reservoir water level after the end of rainfall) 4. Damage to, corrosion of or scum in the drainage facility (pump) 5. Check on the appearance and performance of the operating panel, etc. on site 6. Check on pipes (for any water leakage or joint displacement)	1. Displacement of the catch basin cover 2. Condition of damage to or deformation of the Facility 3. Condition of subsidence, depression or swelling of the ground surface
Inspection method	Visual inspection of the inside of the influent chamber, inspection hole and drainage chamber	Visual inspection of the Facility appearance
Record	Record of inspection results	
Normal cleaning method	1. Removal of fallen leaves and dirt in the influent chamber and drainage chamber 2. Removal of sludge deposited in the influent chamber and drainage chamber 3. Cleaning of the screens	

In addition, it is also important to make sure that the Facility is properly functioning by measuring the waver levels at the time of storage and drainage as shown in Table 3.5-4.

Table 3.5-4 Check on Water Level

Point to be checked	Reason
Whether or not the water level is full	Overflow from the overflow pipe may affect the downstream part.
Whether or not the water level is rapidly rising/falling	Rapid water level change may lead to damage to the Facility.
	Rise of the water level may be caused by blockage of screens or drainage facility.
	Fall of the water level may be caused by damage to the water impermeable sheet.
Drainage condition	The drainage volume may be decreased by blockage of screens or drainage facility.

(2) Extra inspection

1) Frequency of inspection

If heavy rain is expected based on weather information, etc., extra inspection shall be conducted in advance to preserve the functions. Extra inspection shall also be conducted when abnormality is found in any part of the Facility or notification is received from any party concerned after the completion of engineering works in the area around the Facility.

2) Inspection specifics

The inspection specifics shall follow those of regular inspection.

(3) Inspection after earthquake

1) Inspection frequency

Inspection after earthquake shall be conducted promptly when an earthquake of intensity 4 or higher occurred. If the administrator has established the specifics concerning inspection after earthquake, they shall be followed.

2) Inspection specifics

The inspection specifics shall follow those of regular inspection.

(4) Detailed examination

Detailed examination is an examination of disturbed areas found in regular inspection, etc. and intended for deciding whether or not measures need to be taken by examining the cause.

The purposes of the examination include:

1) To clarify the conditions of the disturbance
2) To grasp the degree of soundness of the structure
3) To estimate the cause of the disturbance and formulate appropriate countermeasures.
4) To confirm the effect of the countermeasures after their implementation.

Based on the results of the detailed examination, the content of the judgment and specific measures shall be discussed and countermeasures implemented as required.

(3) Cleaning

Cleaning shall be carried out for the purpose of ensuring the functions of the Facility. The method of cleaning shall be established based on the scale, type and influent water quality of the Facility, and cleaning shall be conducted systematically.

(Commentary)

Cleaning shall be carried out for the purpose of preventing the generation of any foul odor or hazardous gas due to decomposition of organic matters contained in the influent water, ensuring the storage capacity or infiltration function and preventing functional degradation caused by attachment of oil or fat to orifices, screens, etc.

The specifics of cleaning include removal of sediment, dirt, fallen leaves, roots, etc. and carrying them out of the Facility and, at the same time, it is important to clean the area around the Facility. In addition, attention must be paid to prevent rinse water, etc. from entering the Facility during cleaning.
The standard amount of sediment deposited is 1.5 m^3/year per 1 ha of catchment area for rainwater regulating reservoirs provided in sewerage facilities. As the method of cleaning, manual labor for smaller scales and combination with use of machines for larger scales are efficient.

Methods of cleaning include the following. The technique shall be selected according to the products and purpose of the Facility.
1) Use of high-pressure cleaning and sludge suction vehicles (cleaning of deposited sediment)
2) Storage of water and agitation of water in the reservoir (cleaning of the entire reservoir)

Detachable screens, etc., may be collectively cleaned in a factory. Simply replacing them and cleaning the catchment is sufficient if spares are prepared on site, which is efficient in terms of the reduction of work time and treatment of the rinse water discharged.

Safety measures shall be taken when entering the Facility during cleaning. As a safety measure, the amount of oxygen and nonexistence of hazardous gases shall be checked (safety criteria: oxygen concentration of 18% or higher and hydrogen sulfide concentration of 10 ppm or lower).

Oxygen deficiency may occur during cleaning. To meet the safety criteria mentioned above, ventilation by blowers, etc. shall be ensured in conformity to the Rules for the Prevention of Oxygen Deficiency, etc. If one period of ventilation is not enough to maintain safe conditions, ventilation must be carried out continuously.

Ensure sufficient illuminance during work. Cleaning by using high-pressure water involves danger and workers familiar with handling of high-pressure cleaning vehicles shall be elected. For cleaning in the reservoir, observers capable of constantly checking on safety according to the condition of work shall be stationed to allow constant communication with the aboveground personnel.

(4) Repair

Measures shall be promptly taken when repair is judged to be necessary by inspection.

(Commentary)
Measures shall be promptly taken when repair is judged to be necessary by inspection.

Immediate repair is necessary for maintaining safety and functions in some cases and measures can wait while the developments are watched for some time in others. When repair is insufficient, replacement or new installation is necessary.

Displacement of or damage to the screen in the influent part of the Facility may allow entry of dirt or small animals into the reservoir, leading to degradation of the storage and infiltration functions. For this reason, repair or replacement shall be immediately carried out if any screen displacement or damage is found.

For reservoirs that allow inspection of the inside through the inspection hole, etc., if any deformation, buckling or damage of the storage structure is found in inspection, the cause must be promptly examined and appropriate measures taken. Any damage to the sheet must be repaired without delay.
If any depression or subsidence of the ground surface is generated, the cause and extent of the effect must be examined and appropriate measures taken. Depression and subsidence of the ground surface is

often caused by inadequate backfilling or rolling compaction after excavation rather than the Facility itself and attention shall be paid to avoid useless attempts to find the cause in the Facility.

(5) Facility Register

For proper maintenance of the Facility, Facility Register describing the structure, functions, etc. of the Facility shall be prepared and maintained.

(Commentary)
For proper maintenance of the Facility, Facility Register describing the facility structure (storage capacity, reservoir shape, location and structure of the influent and drainage sections and location and structure of the reservoir inspection hole) and functions (settling function of the grit basin, grit collecting function inside the reservoir), etc. and maintained. Documents showing the piping path from the Facility to the drainage destination, overburden and offset and a copy of permission of connection to the drainage destination and photos of under construction shall also be maintained.

The items to be recorded in the Facility Register shall be as listed below:
- (i) Facility name and location
- (ii) Year, month and date of completion
- (iii) Owner and supervisor
- (iv) Overburden of the reservoir
- (v) Embedding depth
- (vi) Reservoir height
- (vii) Reservoir shape
- (viii) Sheet type and structure
- (ix) Method of connection with the influent and effluent pipes
- (x) Structure of the influent and drainage sections
- (xi) Groundwater level
- (xii) Location diagram showing the relationships with buildings in the surrounding area

(6) Maintenance Records

For proper maintenance of the Facility, maintenance records shall be maintained.

(Commentary)
For appropriate preservation of the functions of the Facility, it is important to continue administrative operations. For that reason, records of cleaning, repair, etc. should preferably be maintained as maintenance records.

(7) Measures against Disasters and Accidents

As part of crisis management against disasters and accidents assumed, it is necessary to grasp the conditions of the respective facilities for appropriate handling in the event of such phenomena.

(Commentary)
Possible causes of disasters and accidents assumed include:
1) Generation of buoyancy in the reservoir due to abnormal rise of the groundwater level as a result of a concentrated downpour, etc. to cause the reservoir to be destroyed
2) Earthquake of an intensity exceeding the design value to cause the reservoir to be destroyed
3) Vertical load (heavy vehicles, sediment, etc.) exceeding the design value on the ground surface above the reservoir to cause the reservoir to be destroyed
4) Degradation of the strength caused by bonfire heat or chemical leakage above the reservoir to cause the reservoir to be destroyed

If any of these problems occurs in disasters or accidents, making use of the Facility Register is useful for prompt restoration activities.

(8) Maintenance System

For proper maintenance of the Facility over a long time, the installer of the Facility shall cooperate with the administrator and user to ensure appropriate maintenance.

(Commentary)
To maintain a certain level of control of the Facility installed in various locations such as residential areas, parks and roads, establishment of an appropriate maintenance system is important. The following describes the basic concept of the maintenance system in private and public facilities.

(1) Private facilities
For private facilities, management entities are residents or corporations and close cooperation and collaboration between the public and private sectors is required for fulfilling the public roles such as runoff mitigation and groundwater recharge. When the Facility plays public roles, in particular, establishment of a maintenance system based on guidance by the local government as shown in Fig. 3.5-2 is necessary and it is desired to conclude an administration agreement, etc. between the local government and the residents, corporation, etc.

Independent houses often have individual infiltration facilities and the residents tend to readily understand the necessity of maintenance of the Facility.

(2) Public facilities
For the Facility installed in public facilities, if the installer and administrator are different, it is necessary for the two parties to keep close contact with each other and clarify the division of expense, which party is responsible and method of maintenance. In addition, it is preferable that a notification board, etc. be provided so that the facility user can contact the administrator if any abnormality is found in the Facility to request for an understanding about administration of the Facility and cooperation.

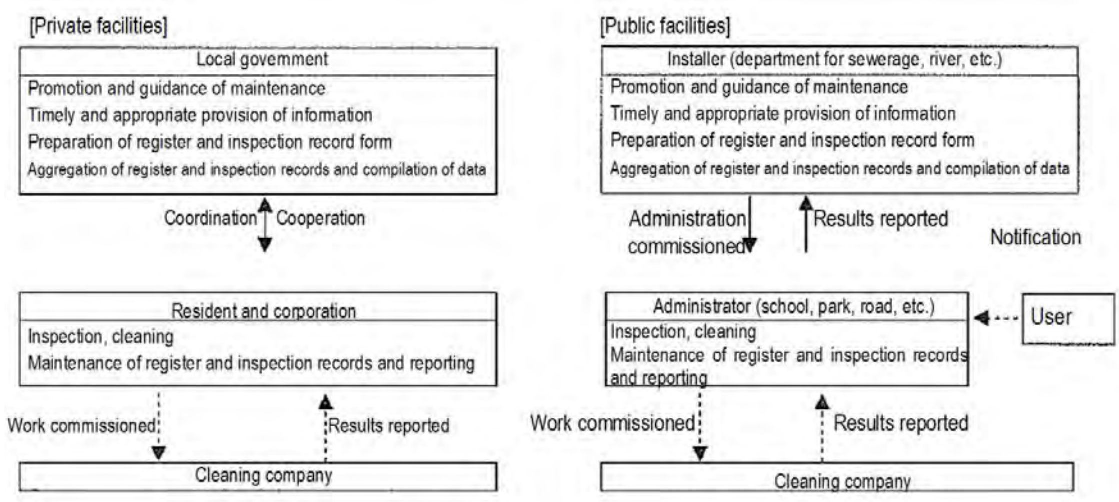


Figure 3.5-2 Maintenance System

(9) Matters Prohibited above the Facility after Completion

To ensure the functions of the Facility, adequate considerations shall be given to the following acts committed above the Facility after its completion. For ensuring that the prohibited matters are widely known, means such as installation of a notification board describing the prohibited matters shall be considered.
(1) Entry of heavy machines or temporary storage of banking or construction materials, etc. exceeding the assumed weight
(2) Bonfire
(3) Use of chemicals
(4) Other

(Commentary)
To prevent entry of vehicles other than the relevant service vehicles, measures shall be taken such as installation of barricades for entry prevention to protect the Facility. When asphalt paving is provided above the Facility, the measures shall be taken until the completion of paving.

(1) Entry of heavy machines or temporary storage of banking or construction materials, etc. exceeding the assumed weight
If a heavy machine exceeding the assumed weight enters or banking or construction materials are temporarily stored above the reservoir, the storage structure may be buckled or deformed, leading to destruction of the reservoir. In addition, crane works or soil retainer drawing works that may apply more load than assumed shall not be carried out above the reservoir.

(2) Bonfire
Making a bonfire above the reservoir after completion may cause deformation or strength degradation of the storage structure due to the heat. It may also lead to a fire.

(3) Use of chemicals
The storage structure shall not be in contact with organic solvents, chemicals, mineral oils, etc., which may cause its deterioration. Entry of gasoline, oils, etc. shall also be prevented.

(4) Other
Entry of drainage water, etc. at high temperature, which may cause strength deterioration of the storage structure, shall be prevented.

For places that may allow entry of unspecified vehicles, residents, etc. such as schoolyards, parks and public squares, installation of a notification board listing the prohibited matters including entry of heavy vehicles and bonfire shall be considered. Trial digging and adjacent construction works near the Facility may cause the storage structure and sheets to be damaged. Accordingly, installation of offset indication piles, etc. on site shall also be considered in order to indicate the location of installation.

3.6 Evaluation of Effect of the Facility

3.6.1 Evaluation on Effect of Decrease for Peak Discharge

(1) Evaluation on Effect of Decrease for Peak Discharge of the Facility

Effect of peak runoff reduction shall be evaluated by comparing peak inflow with outflow.

(Commentary)
The effect of decrease for peak discharge shall be evaluated comparing hydrograph of discharge outflow after runoff control with hydrograph of discharge inflow showing below.

Effect of decrease for peak discharge = Qinp – Qoutp

Qinp : Peak Discharge Inflow before runoff control (m^3/s)

Qoutp : Peak Discharge Outflow after runoff control(m^3/s)

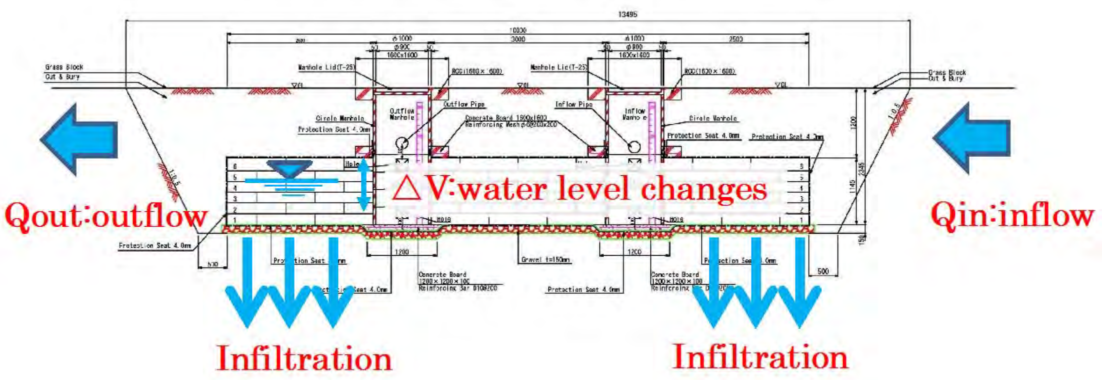


Figure 3.6-1 Explanation on Effect of decrease for peak discharge

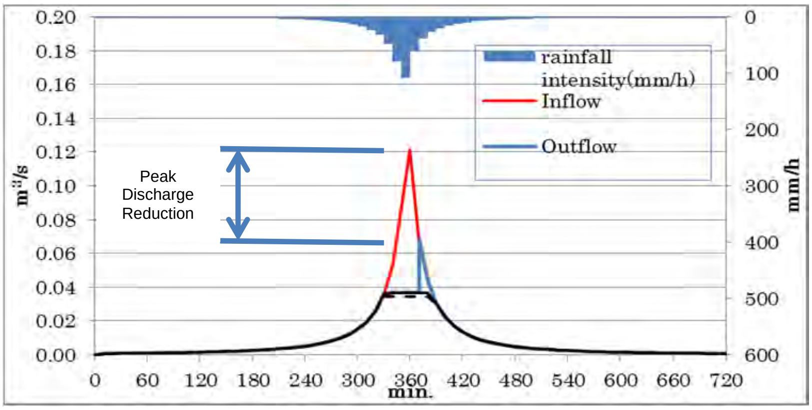


Figure 3.6-2 Effect of Decrease for Peak Discharge (Image)

3.6.2 Evaluation on Effect of Decrease for Total Volume of Discharge

(1) Evaluation on Effect of Decrease for Total Volume of Discharge

Effect of outflow reduction shall be evaluated by comparing total inflow with total outflow.

(Commentary)
Effect of Decrease for Total Volume of Discharge shall be calculated by formula which is shown below.

Decrease for Total Volume of Discharge (%) = $\Delta V1 / \Delta Va$

$\Delta V1 = (\Sigma Qin - \Sigma Qout)$

ΣQin : Total Volume of Inflow (m^3)

ΣQout : Total Volume of Outflow after runoff control (m^3)

ΔVa = Average amount of rain fall of institution catchment area(mm) * institution catchment area(ha)

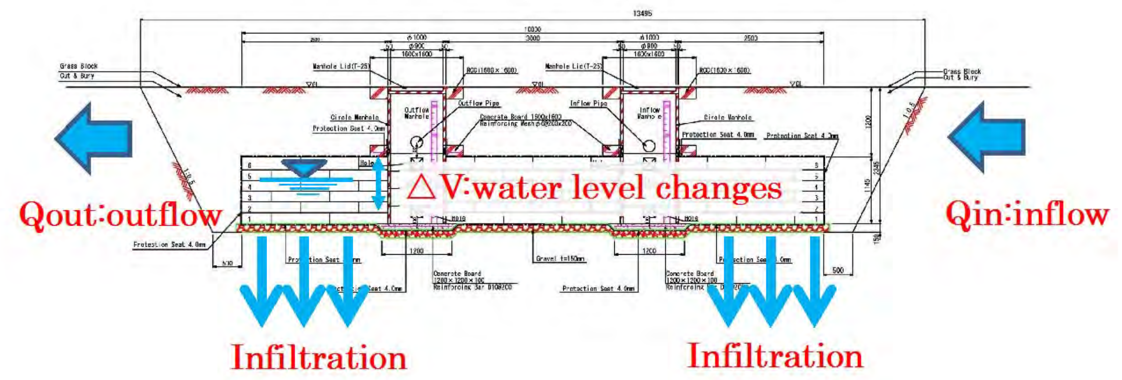


Figure 3.6-3 Explanation on Effect of decrease for total volume of discharge

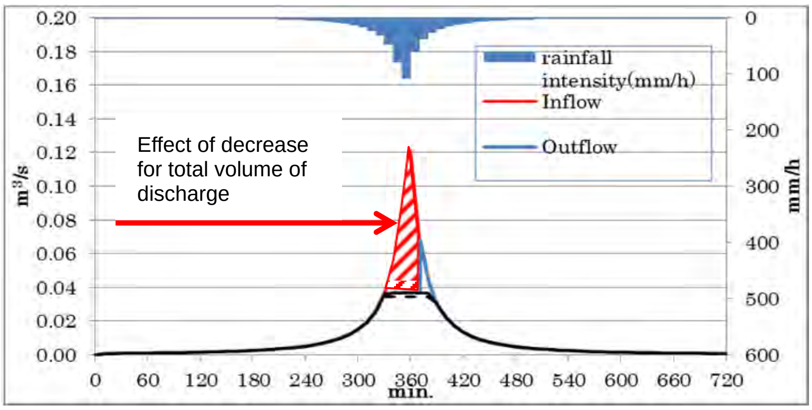


Figure 3.6-4 Effect of decrease for total volume of discharge (Image)

CHAPTER 4 SITU IMPROVEMENT

4.1 Policy for Rehabilitation and Improvement of Various Types of Situ

At present, there are various types of Situ in the river basin. Those types of Situ have control effects against the small or medium scale of flood. However, due to the land use change led by the rapid economic growth in Indonesia, the number of Situ tends to decline. Thus, the basic policies for rehabilitation, conservation and improvement of Situ were clarified.

4.1.1 Policy for Rehabilitation and Improvement of Situ

The policies for the rehabilitation and improvement of Situ in step are as follows.

(1) Rehabilitation of Situ

Purpose : to avoid the reduction and/or disappearance of Situ, and to maintain the function of Situ as water source
Method : dredging, construction of dike, improvement of surrounding areas
Flood Control Effect : not to increase the flood control effect more than before works

(2) Improvement of Situ to enhance Runoff Control Effect

Purpose : to increase temporary storage capacity (flood control volume) of rainfall
Method : current water use, land use in surrounding areas, and improvement of spillway
Flood Control Effect : to be planned to increase a certain level of flood control effect
Concerns : as a result of spillway improvement, the following concerns shall be taken into account:

- To degrade the water use of Situ
- To increase flow volume to the downstream
- To make the dike unstable
- To rise water level causing inundation in the surrounding areas

(3) Improvement of Situ to increase Flood Safety Level against Large Scale Rainfall

Purpose : to ensure the safety of Situ in case of large scale rainfall
Method : to construct dike and spillway with the same safety level as dam, to improve downstream river sections and surrounding areas of Situ
Flood Control Effect : to be planned to increase a certain level of flood control effect
Concerns : it might cause a large impact to the current water use and land use in surrounding areas. Thus, it is necessary to examine the facility plan on design water level, specifications of structures, improvement of downstream river section, and influenced surrounding areas in coordination with the related stakeholders sufficiently. The detail design shall be in line with the dam construction.

Among the above, item (1) has been carried out by the Indonesian government, and item (3) can be examined in line with dam planning. Therefore, in this manual, item (2) for the improvement of Situ for the enhancement of runoff control effect will be described.

4.2 Situ Improvement for Increasing Flood Control Capacity

4.2.1 Situ Improvement Policy

By converting some portion of water use capacity of an existing *Situ* into flood control capacity, the *Situ* is able to reduce the flood peak discharge.

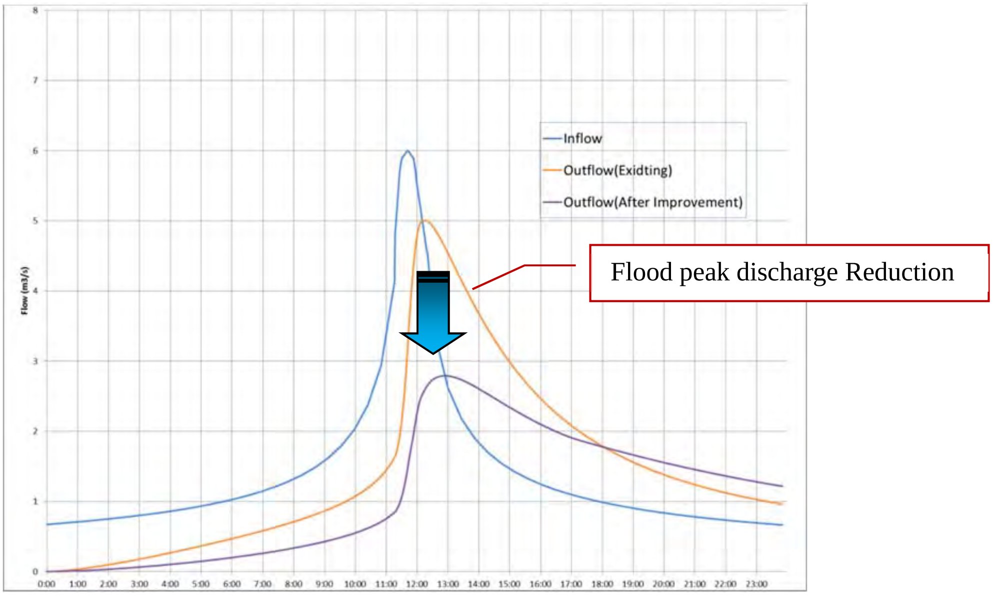


Figure 4.2-1 Conceptual Diagram on Peak Discharge Reduction by Situ Improvement

There are several ways to increase flood control capacity of *Situ* as shown below. Alternative (a) seems to be the easiest measure from the viewpoint of land acquisition.

(a) Lowering the water level in normal times by adding an opening on the spillway
(b) Increasing the water level in flood times by spillway and dike heightening
(c) Increasing the storage capacity by Situ-area expansion work

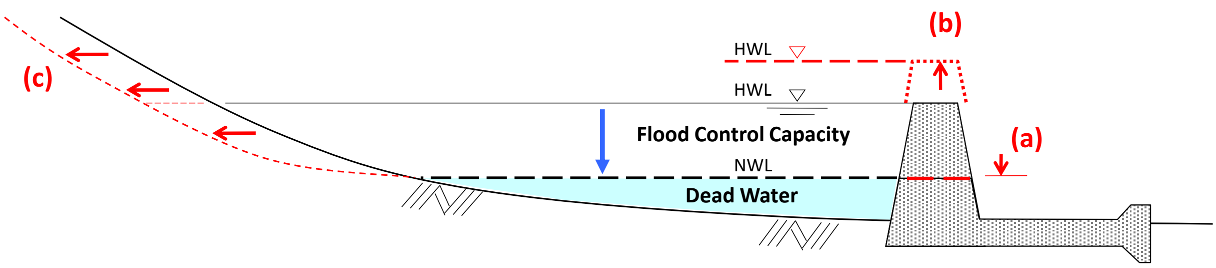


Figure 4.2-2 Conceptual Diagram on Methodology of Situ Improvement

4.2.2 Planning and Effect Evaluation

(1) Design Scale

Since a spillway of *Situ* was designed only for irrigation use, it does not have enough flow capacity against flood flows. Therefore, set the design scale in relation to maximum flow capacity of the existing spillway.

(2) Runoff Calculation and Flood Control Calculation

1) Basic Concept

- Flood control effect by *Situ* improvement shall be evaluated at just downstream point from the spillway.

- In CFMP for decreasing the damage from a flood with 50-year return period in the Ciliwung River, flood control effect by individual *Situ* shall not be evaluated.
- In a flood control plan for a sub-basin, flood control effect by Situ improvement is taken into account.

2) Runoff Calculation

Runoff calculation shall use a basic rational formula.

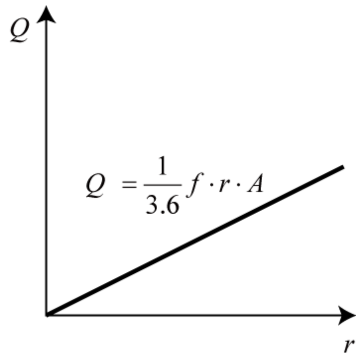
(a) Rational Formula

Considering the Situ basin being relatively narrow, the runoff calculation for Situ shall employ a rational formula generally used as the runoff analysis method that immediately converts rainfall into the flow rate and is suitable for medium and small rivers and urban areas.

$$Q = \frac{1}{3.6} f \cdot r \cdot A \qquad \text{...........(1)}$$

where,

Q	: maximum flood discharge (m^3/s)
f	: dimensionless runoff coefficient
r	: rainfall intensity within time t_c
A	: catchment area (km^2)



(b) Flood Concentration Time

Flood concentration time (t_c) is the sum of inlet time (t_i) and flow time (t_f). Inlet time is a length of time taken to transport a rainfall at the most upstream in a basin to its river channel. Flow time is a length of time taken to discharge a floodwater at the most upstream river channel to a downstream reference point.

$$t_c = t_i + t_f \qquad \cdots\cdots (2)$$

where,

t_i	: inlet time (min)
t_f	: flow time (min)

Inlet time (t_i) was calculated as follows.

(i) Find the inlet point, catchment area of which is 2 km^2
(ii) Set the inlet time as follows.
t_i = 30 (min)
(iii) When the catchment area (A) at the farthest point of the channel is clearly judged to be less than 2 km^2, calculate the inlet time using the following formula.

$$t_i = \frac{30\sqrt{A}}{\sqrt{2}} \qquad \cdots\cdots (3)$$

Flow time (t_f) was calculated by means of Kraven's Formula, which gives relations between riverbed slope and flow velocity shown below.

$$t_f = L / (V \times 60) \quad \cdots (4)$$

where,

L: length of river channel from its outlet point to the farthest point (m)
V: flow velocity (m/s)

Table 4.2-1 Relationship between Riverbed Slope and Flow Velocity

Riverbed Slope (I_b)	I_b > 1/100 (steep slope)	1/100 > I_b > 1/200	I_b < 1/200 (mild slope)
Flow Velocity (V)	3.5 m/s	3.0 m/s	2.1 m/s

(c) Rainfall Intensity Formula

Rainfall intensity calculation shall use the existing rainfall intensity formula at the observing station near Situ.

3) Flood Control Calculation

The following equation describing relation (outflow discharge) = (inflow) – (storage) was used for flood control calculation.

$$\frac{V_2}{\Delta t} + \frac{Q_{o2}}{2} = \frac{V_1}{\Delta t} - \frac{Q_{o1}}{2} + Q_{in} \quad \cdots (5)$$

where,

V_1 : storage (m^3)
V_2 : storage after Δt (m^3)
Q_{in} : inflow (m^3)
Q_{o1} : outflow discharge in relation to V_1 (m^3)
Q_{o2} : outflow discharge in relation to V_2 (m^3)

Also, outflow discharge was obtained by the following formula.

$$Q = C \cdot B \cdot H^{1.5} \quad \cdots (6)$$

where,

C : overflow coefficient (C = 1.8)
B : overflow width (m)
H : overflow depth (m)
(Overflow depth is obtained from H – V curve.)

(3) Example of Calculation and Preliminary Design

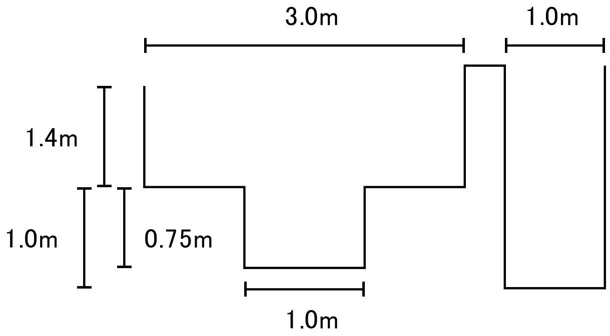
The example of calculation and preliminary design is shown below.

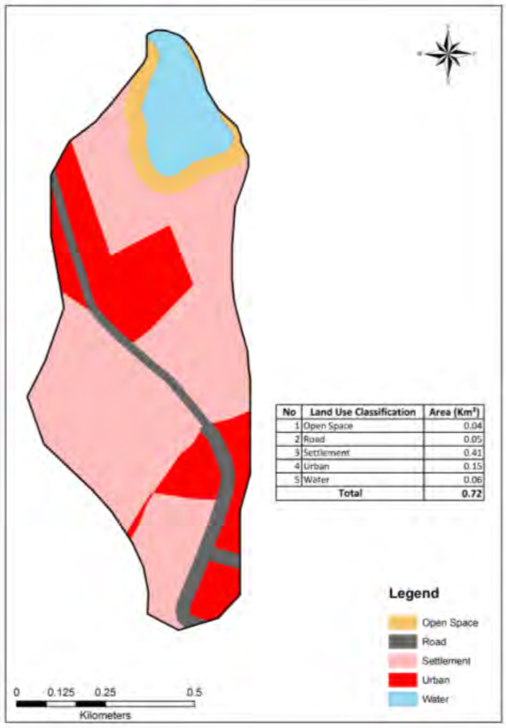
1) Design Criteria

(a) Condition for Analysis

- Return Period: 1/25
- Rainfall Curve: 24-hour middle concentration curve

- Spillway: the existing spillway consists of effluent outlet with 3.0m×1.4m and water supply gate. For the modification of spillway, the effluent outlet will be cut off with 1.0m×0.75m.





(b) Specification of Sub-Basin

- Catchment Area: 71.5ha
- Storage Area: 9.5ha
- Length of River Channel: 1,370m
- Slope of River Channel: (112.5-105.03)/1370=1/183
- Run-off Coefficient: 0.61 (future land use)
- Flood Arrival Time

: Inlet Time=√0.715/√2×30=18min
: Reaching Time=1370/3/60=8min
: Flood Arrival Time=18+8=26min

(c) Rainfall Intensity Formula

Jakarta OBS $r_{25}=1086.9/t^{0.6}-.0884$

(d) Water Level

In accordance with the site survey, it is realized to lower the water level maximum no less than 75cm.

2) Verification of Effect

The effect of the facility against the 1/25 rainfall is shown as follows.

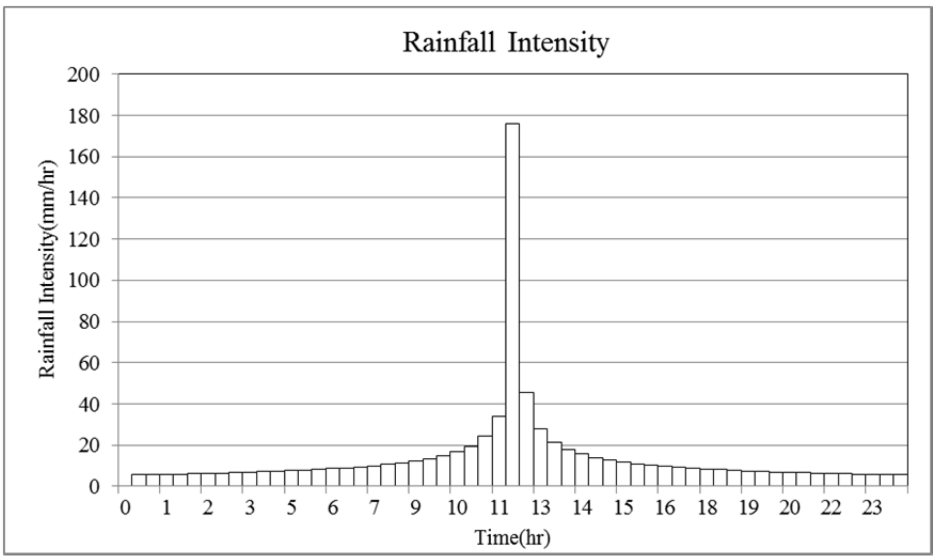


Figure 4.2-3 Rainfall Distribution (24-hour Middle Concentration)

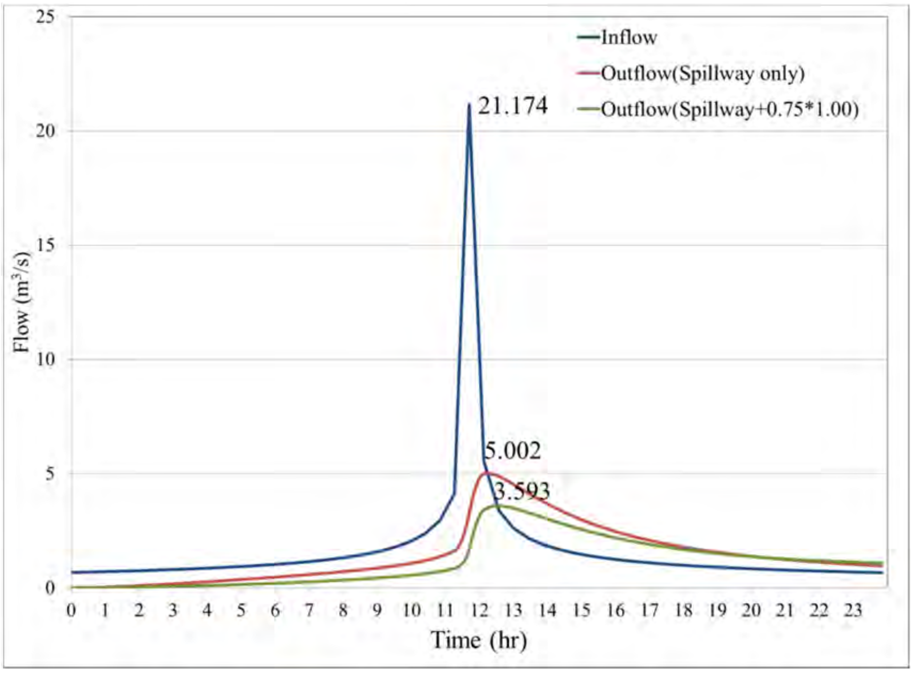


Figure 4.2-4 Deduction Effect of Outflow Discharge by Cutting Off Spillway

As shown in Figure 4.2-4, the maximum outlet discharge will decrease from 5.0 m^3/s to 3.6 m^3/s.

3) Preliminary Design

Based on the above analysis, the preliminary design is conducted. The crown of the dike of downstream spillway will be cut off with width of 100cm×height of 75cm. The preliminary design drawing is shown in Figure 4.2-5.

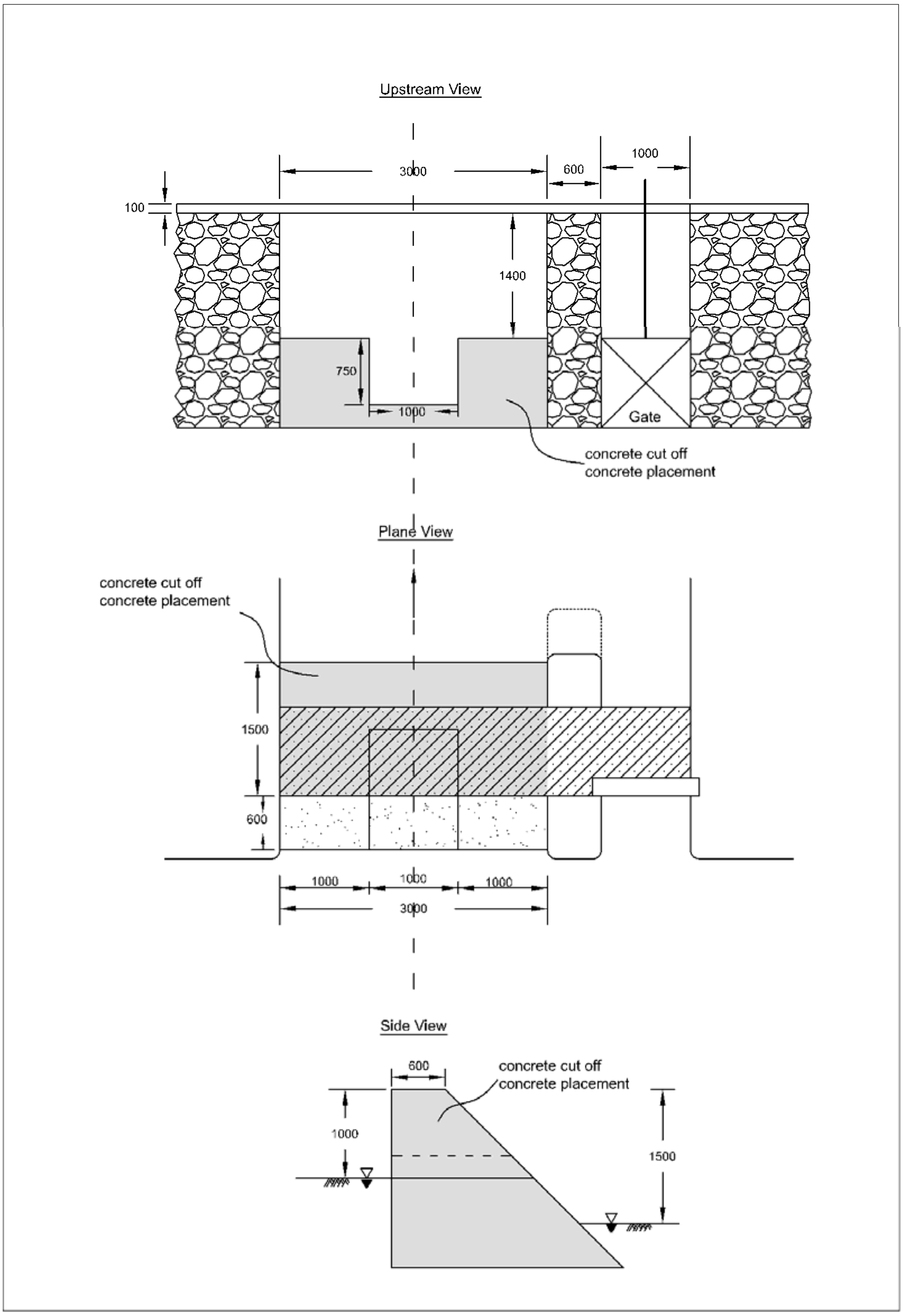


Figure 4.2-5 Modification of Spillway

4.2.3 Consideration

The following subjects shall be considered for the improvement of Situ to increase the runoff control effect.

a) In case that there is no significant difference of water level between Situ and downstream river by improvement of downstream river channel of Situ, it is not appropriate to reduce the normal water level. For ensuring the flood control volume by reducing the water level in flood, it is necessary to conduct overall improvement works of dike and spillway to resist against the increase of normal hydrostatic pressure.
b) In case there is inflow from the outside of the basin through the irrigation channel, this inflow volume shall be evaluated in the calculation of flood control effect.
c) If aquiculture or water transportation can be identified in Situ, it is necessary to determine the water level in consideration of the impact of water level reduction by the improvement works, and to make consensus among the related stakeholders.
d) Normalization work for an upstream river course from a *Situ* may increase peak inflow. In a worst-case, it causes dike overtopping of Situ. As measures against the overtopping, it is necessary to consider necessary measures including a) removal of *Situ*, b) reconstruction of *Situ* as a dam, c) construction of bypass channel, and d) no river improvement at upstream of *Situ*.

4.3 Maintenance

4.3.1 Spillway

The regular inspection shall be conducted to avoid the block out of notches of spillway by garbage, and to check the damage conditions of spillway.

4.3.2 Boundary Area

Conservation/boundary area around *Situ* stipulated in existing regulations shall be maintained in a good condition after the determination of the area and installation of concrete markers to indicate the area. Summary of the regulations about the conservation/boundary area is shown below.

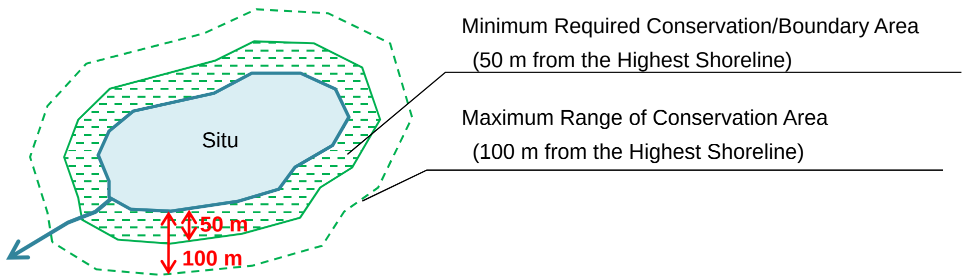


Figure 4.3-1 Range of Conservation/Boundary Area around Situ-Situ

Table 4.3-1 Presidential Decree on Management of Conservation Area

Items	Bahasa Indonesia	English
Name of Regulation	Keputusan Presiden Republik Indonesia Nomor : 32 Tahun 1990 Tentang Pengelolaan Kawasan Lindung	Presidential Decree of the Republic of Indonesia Number: 32 Year 1990 on Management of Conservation Areas
Definition and Purpose of Conservation Area	Kawasan lindung adalah kawasan yang ditetapkan dengan fungsi utama melindungi kelestarian lingkungan hidup yang mencakup sumber alam, sumber daya buatan dan nilai sejarah serta budaya bangsa guna kepentingan pembangunan berkelanjutan. (BAB I, Pasal 1, 1.) Kawasan lindung meliputi kawasan perlindungan setempat dll. (BAB III, Pasal 3, 2.) Kawasan perlindungan setempat terdiri dari kawasan sekitar danau/waduk. (BAB III, Pasal 5, 3.) Perlindungan terhadap kawasan sekitar danau/waduk dilakukan untuk melindungi danau/waduk dari kegiatan budi daya yang dapat menggangu kelestarian fungsi danau/waduk. (BAB IV, Pasal 17)	Conservation area is a area where is defined that its primary function is to protect environmental sustainability covering natural resources, artificial resources, and historical value with ethnic culture for the purpose of sustainable development. (Chapter I, Clause 1, 1) Conservation area includes local conservation area and so on. (Chapter III Clause 3, 2) The local conservation area consists of the area around a lake/reservoir. (Chapter III, Clause 5, 3) Conservation of the area around a lake/reservoir is done to protect the lake/ reservoir from utilization activities that may interfere with preservation of the lake/reservoir's function. (Chapter IV, Clause 17)
Extent of Conservation Area	Kriteria kawasan sekitar danau/waduk adalah daratan sepanjang tepian danau/waduk yang lebarnya proporsional dengan bentuk dan kondisi fisik danau/waduk antara 50-100 meter dari titik pasang tertinggi ke arah darat. (BAB IV, Pasal 18)	Criteria for the area around lake/ reservoir is the ground along the lakeside whose width is proportional with the shape and physical condition of lakes/reservoirs and between 50-100 meters from the water's edge at the time of the highest tide to landward. (Chapter IV, Clause 18)
Allowed Activities in Conservation Area	-	-
Prohibited Activities in Conservation Area	Di dalam kawasan lindung dilarang melakukan kegiatan budi daya, kecuali yang tidak mengganggu fungsi lindung. (BAB VI, Pasal 37, (1)) Kegiatan budi daya yang sudah ada di kawasan lindung yang mempunyai dampak penting terhadap lingkungan hidup dikenakan ketentuan-ketentuan yang berlaku sebagaimana dimaksud dalam Peraturan Pemerintah Nomor 29 Tahun 1986 tentang Analisis Mengenai Dampak Lingkungan. (BAB VI, Pasal 37, (3))	In the conservation area, performing utilization activities, except for activities which do not impair the function of protection, is prohibited. (Chapter VI, Clause 37, (1)) Regarding utilization activities which already exist in the conservation area and have significant impacts on the environment, provisions in the Government Regulation No. 29 year 1986 about Analysis of Environmental Impact will be applicable. (Chapter VI, Clause 37, (3))

Table 4.3-2 Decree of the Minister of Public Works on Boundary Line of River (1/2)

Items	Bahasa Indonesia	English
Name of Regulation	Peraturan Menteri Pekerjaan Umum Nomor : 63/PRT/1993 Tentang Garis Sempadan Sungai, Daerah Manfaat Sungai, Daerah Penguasaan Sungai dan Bekas Sungai	Decree of the Minister of Public Works Number : 63/PRT/1993 on Boundary Line of River, River Utilization Areas, Controlled Areas of River and Former River
Definition and Purpose of Boundary Area	Daerah sempadan danau/waduk adalah kawasan tertentu disekeliling danau/waduk yang mempunyai manfaat penting untuk mempertahankan kelestarian fungsi sungai. (BAB I, Pasal 1, 12)	Boundary area of lake/reservoir is a certain area around a lake/reservoir which has important benefits to maintain sustainability of functions of a river. (Chapter I, Clause 1, 12)
Extent of Boundary Area	Penetapan garis sempadan danau, waduk, mata air dan sungai yang terpengaruh pasang surut air laut mengikuti kriteria yang telah ditetapkan dalam keputusan Presiden R.I Nomor: 32 Tahun 1990 tentang Pengelolaan Kawasan Lindung, sebagai berikut: a. Untuk danau dan waduk, garis sempadan ditetapkan sekurang-kurangnya 50 (lima puluh) meter dari titik pasang tertinggi kearah darat. (BAB II, Pasal 10)	As for the establishment of a boundary line of a lake,a reservoir, a spring, and a river which is affected by tidal change, follow the established criteria in Presidential Decree of the Republic of Indonesia Number: 32 Year 1990 on Management of Conservation Areas, as follow: a. For lakes and reservoirs, a boundary line shall be set at least 50 (fifty) meters from the point of the highest tide to landward. (Chapter II, Clause 10)
Allowed Activities in Boundary Area	Pemanfaatan lahan di daerah sempadan dapat dilakukan oleh masyarakat untuk kegiatan-kegiatan tertentu sebagai berikut: a. Untuk budidaya pertanian dengan jenis tanaman yang diijinkan. b. Untuk kegiatan niaga, penggalian dan penimbunan. c. Untuk pemasangan papan reklame, papan penyuluhan dan peringatan, serta rambu-rambu pekerjaan. d. Untuk pemasangan rentangan kabel listrik, kabel telepon dan pipa air minum. e. Untuk pemancangan tiang atau pondasi prasarana jalan/jembatan baik umum maupun kreta api. f. Untuk penyelenggaraan kegiatan-kegiatan yang bersifat social dan masyarakat yang tidak menimbulkan dampak merugikan bagi kelestarian dan keamanan fungsi serta fisik sungai. g. Untuk pembangunan prasarana lalu lintas air dan bangunan pengambilan dan pembuangan air. (BAB II, Pasal 11, (1))	As for the land use of the boundary area, following certain activities can be done by people: a. Cultivation by means of allowed types of plants b.Commercial activities, excavation and landfilling c. Installation of billboards, information and notice boars, also work signs d. Instalation of electric wires, telephone cables and water pipes e. Piling pillars or foundations of road/bridge and railway infrastructures f. Implementation of social and community activities which does not have adverse affects on sustainability and safety of physical function of rivers g. Construction of water traffic infrastructure, and intake and drainage facilities (Chapter II, Clause 11, (1))

Table 4.3-3 Decree of the Minister of Public Works on Boundary Line of River (2/2)

Items	Bahasa Indonesia	English
Prohibited Activities in Boundary Area	Pada daerah sempadan dilarang: a. Membuang sampah, limbah padat dan atau cair b. Mendirikan bangunan permanen untuk hunian dan tempat usaha (BAB II, Bagian Keempat, Pasal 12)	In the border areas is prohibited: a. Disposing of garbage and solid waste or liquid b. Establishing permanent buildings for residential and business premises
Others	Pejabat yang berwenang dapat menetapkan suatu ruas di daerah sempadan untuk membangun jalan inspeksi dan/atau bangunan sungai yang diperlukan, dengan ketentuan lahan milik perorangan yang diperlukan diselesaikan melalui pembebasan tanah. (BAB II, Pasal 11, (3))	A competent authority can designate a segment in a bounary area to build required inspection roads and/or river structures, with provisions of private properties which need to be resolved through land acquisition. (Chapter II, Clause 11, (3))