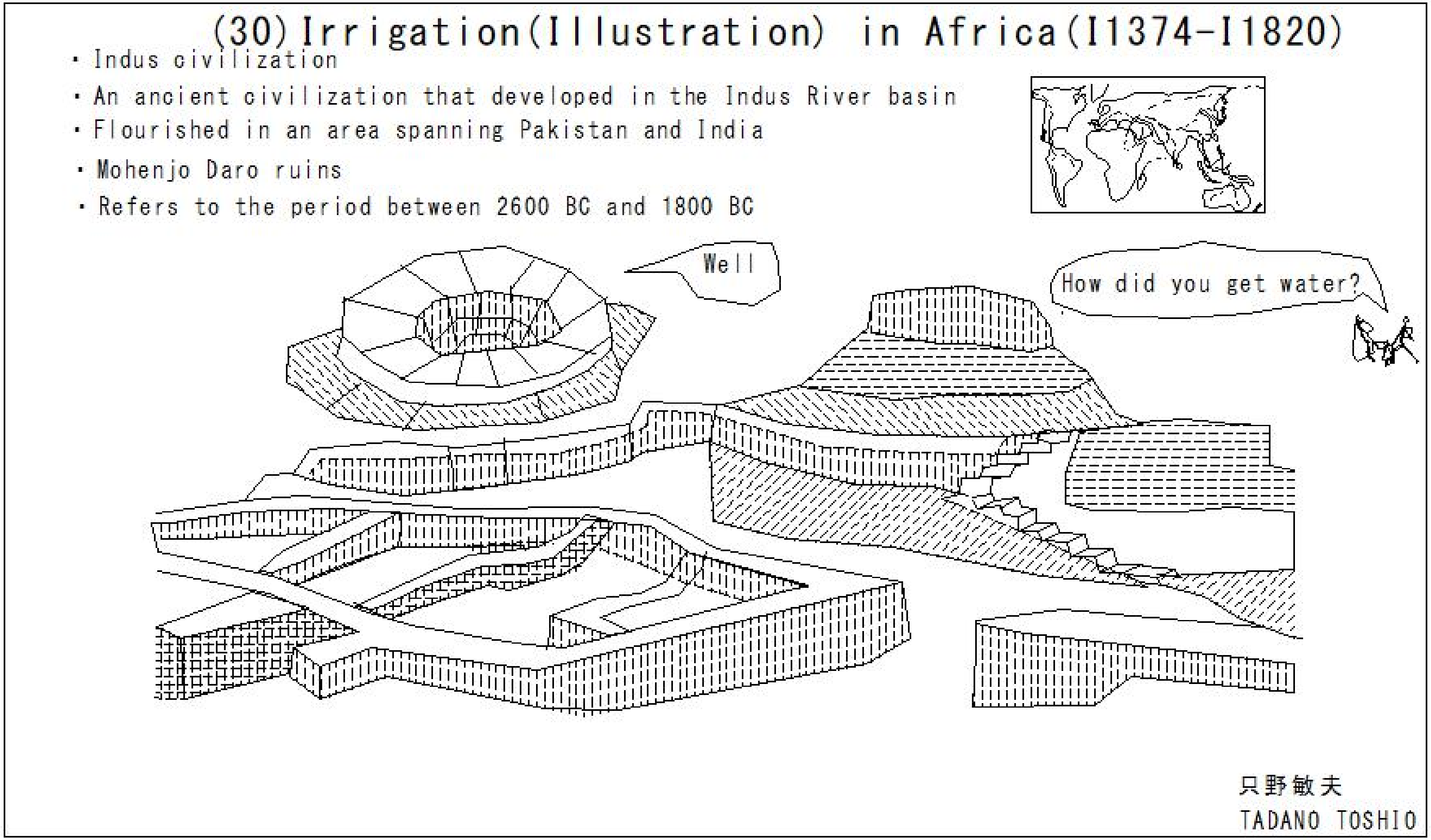
(30)Irrigation(Illustration) in Africa(I1374-I1820)



Reference

1 土木工学ハンドブック 土木学会編 技報堂
Civil Engineering Handbook Edited by Japan Society of Civil Engineers GIHODO SHUPPAN Co., Ltd.

2 農業土木ハンドブック 農業土木学会編 丸善株式会社
Agricultural civil engineering handbook Japan Society of Agricultural Civil Engineers Maruzen Co., Ltd.

3 林業土木ハンドブック 千代田出版
Forestry Civil Engineering Handbook Chiyoda Publishing Co., Ltd.

4 図説土木用語事典 実教出版
Illustrated Dictionary of Civil Engineering Terms Jikkyo Publishing

5 応用地質用語集 東洋書店
Glossary of applied geological terms Toyo Shoten Co., Ltd.

6 実用英和対訳 土木用語辞典 工学出版株式会社
Practical English-Japanese translation Dictionary of civil engineering terms Engineering Publishing Co., Ltd.

7 農業土木用語集 東洋書店
Glossary of agricultural civil engineering terms Toyo Shoten Co., Ltd.

8 土木施工用語集 東洋書店
Glossary of civil engineering construction terms Toyo Shoten Co., Ltd.

9 土木コンクリート用語集 東洋書店
Glossary of civil engineering and concrete terms Toyo Book Book Store

10 土木用語辞典 東京工学研究会編 工学出版株式会社
Dictionary of civil engineering terms Edited by Tokyo Engineering Study Group Engineering Publishing Co., Ltd.

11 図解 土質・基礎用語集 東洋書店
Illustrated Glossary of Soil Characteristics and Basic Terms Toyo Shoten Co., Ltd.

12 農業土木設計 農業土木施工 水循環 文部科学省
Agricultural civil engineering design Agricultural civil engineering construction Water cycle Ministry of Education, Culture, Sports, Science and Technology

13 かんがい、かんがい施設、農業水文、農地排水 コロナ社
Irrigation, irrigation facilities, agricultural hydrology, farmland drainage Corona Publishing

14 ハンディブック 土木 オーム社
Handy Book Civil Engineering Ohmsha

Reference

①	ため池管理マニュアル Reservoir Management Manual	農林水産省 農村振興局 整備部 防災課 Ministry of Agriculture, Forestry and Fisheries, Rural Development Bureau, Development Department, Disaster Prevention Division
②	ため池の基礎知識(1)(2) Basic information about reservoirs Fukuoka Prefectural Reservoir (1)(2)	福岡県ため池管理保全支援センター Fukuoka Prefectural Reservoir Management and Conservation Support Center
③	土地改良事業設計指針(ため池整備)案 Land Improvement Project Design Guidelines (Reservoir Development) Propos	農村振興局:農林水産省 Rural Development Bureau: Ministry of Agriculture, Forestry and Fisheries
④	農業用ため池廃止工事の設計に関する手引き Guide for the design of agricultural reservoir decommissioning works	農林水産省農村振興局防災課 Ministry of Agriculture, Forestry and Fisheries, Rural Development Bureau, Disaster Prevention Division

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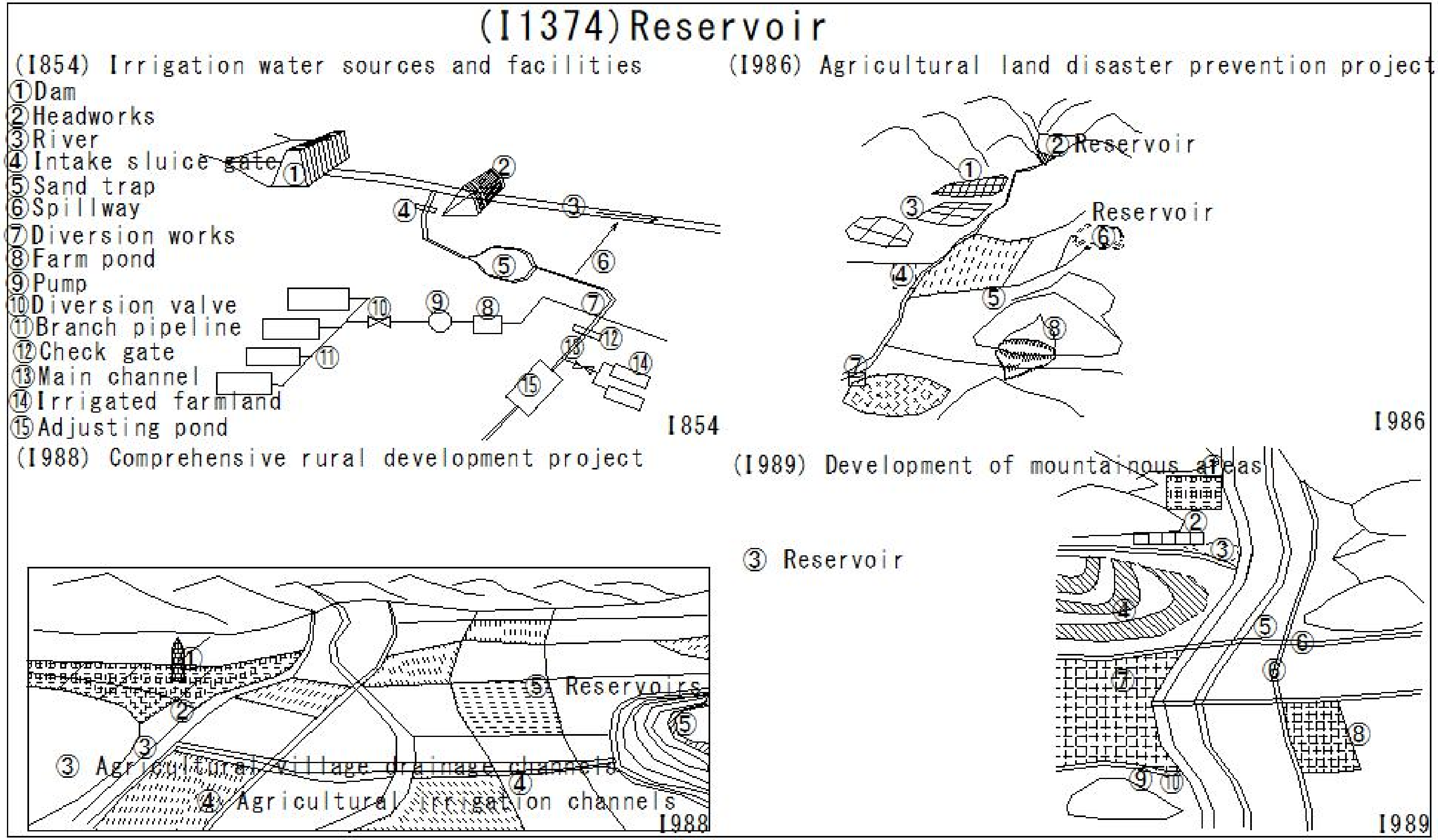
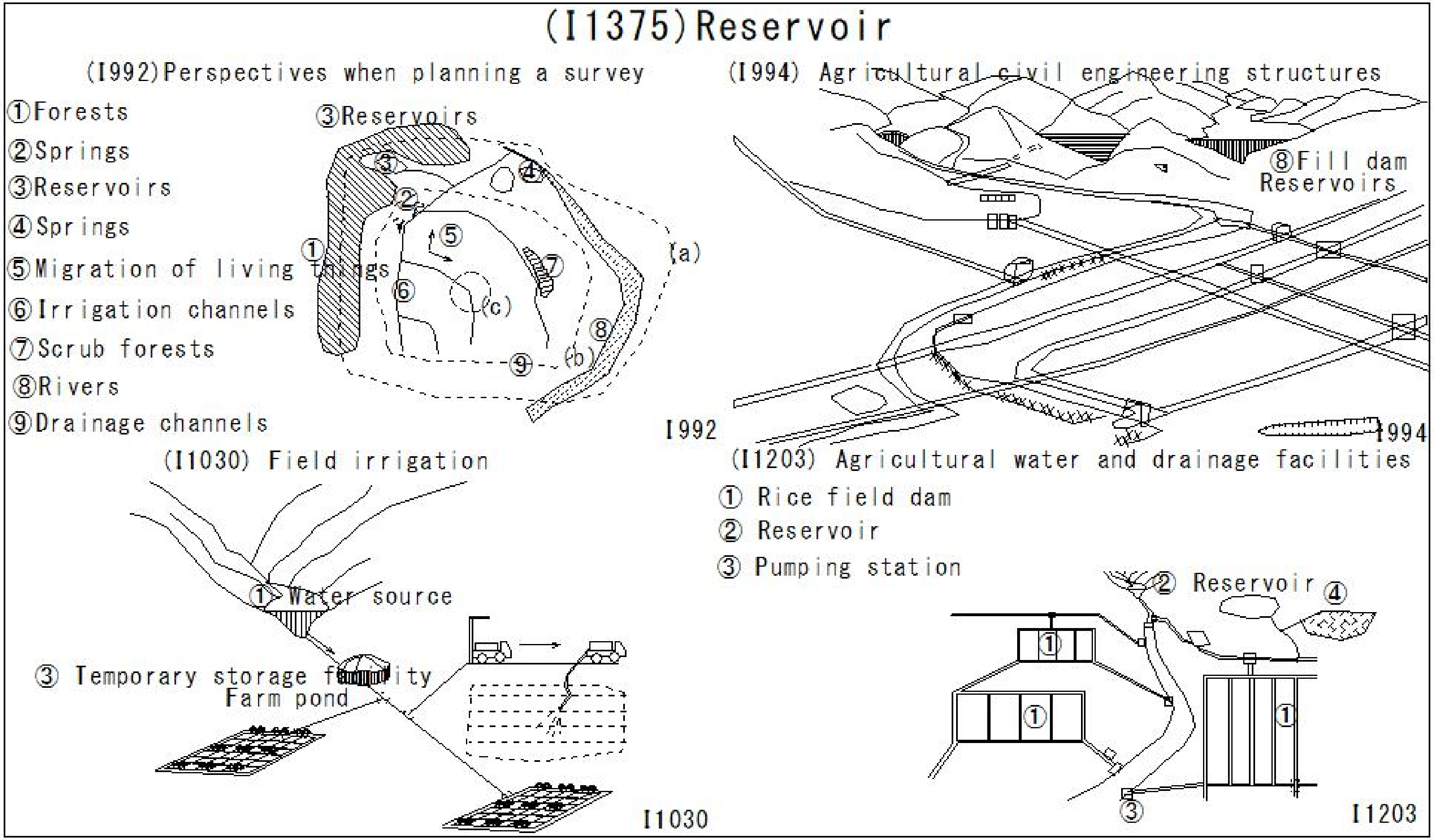
(I1797) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1798) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1799) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1800) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1801) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1802) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1803) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1804) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1805) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1806) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1807) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1808) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1809) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1810) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1811) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1812) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1813) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1814) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1815) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs

(I1816) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1817) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1818) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1819) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs
(I1820) Abolition of agricultural reservoirs	Abolition of agricultural reservoirs

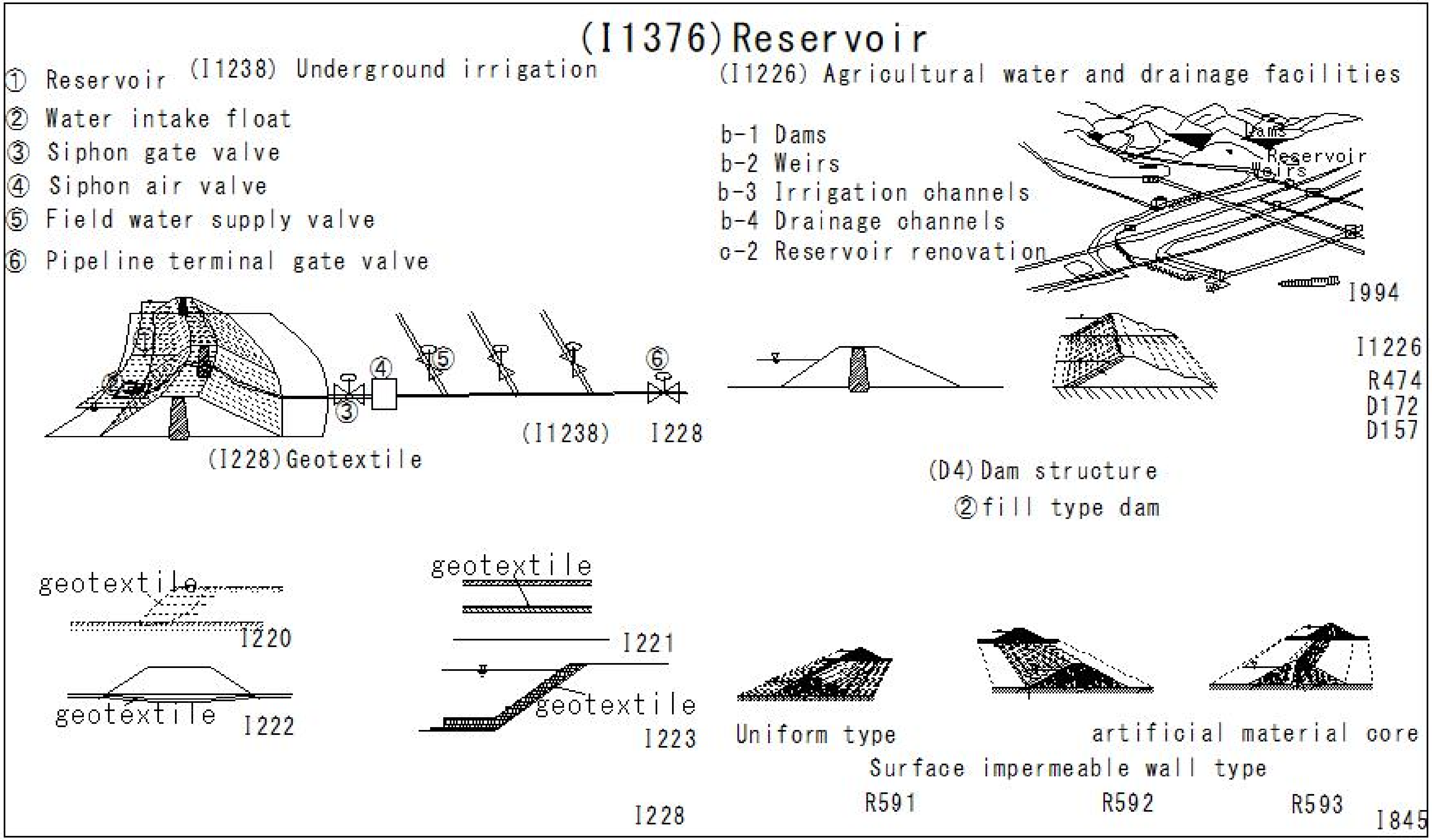
(I1374)Reservoir



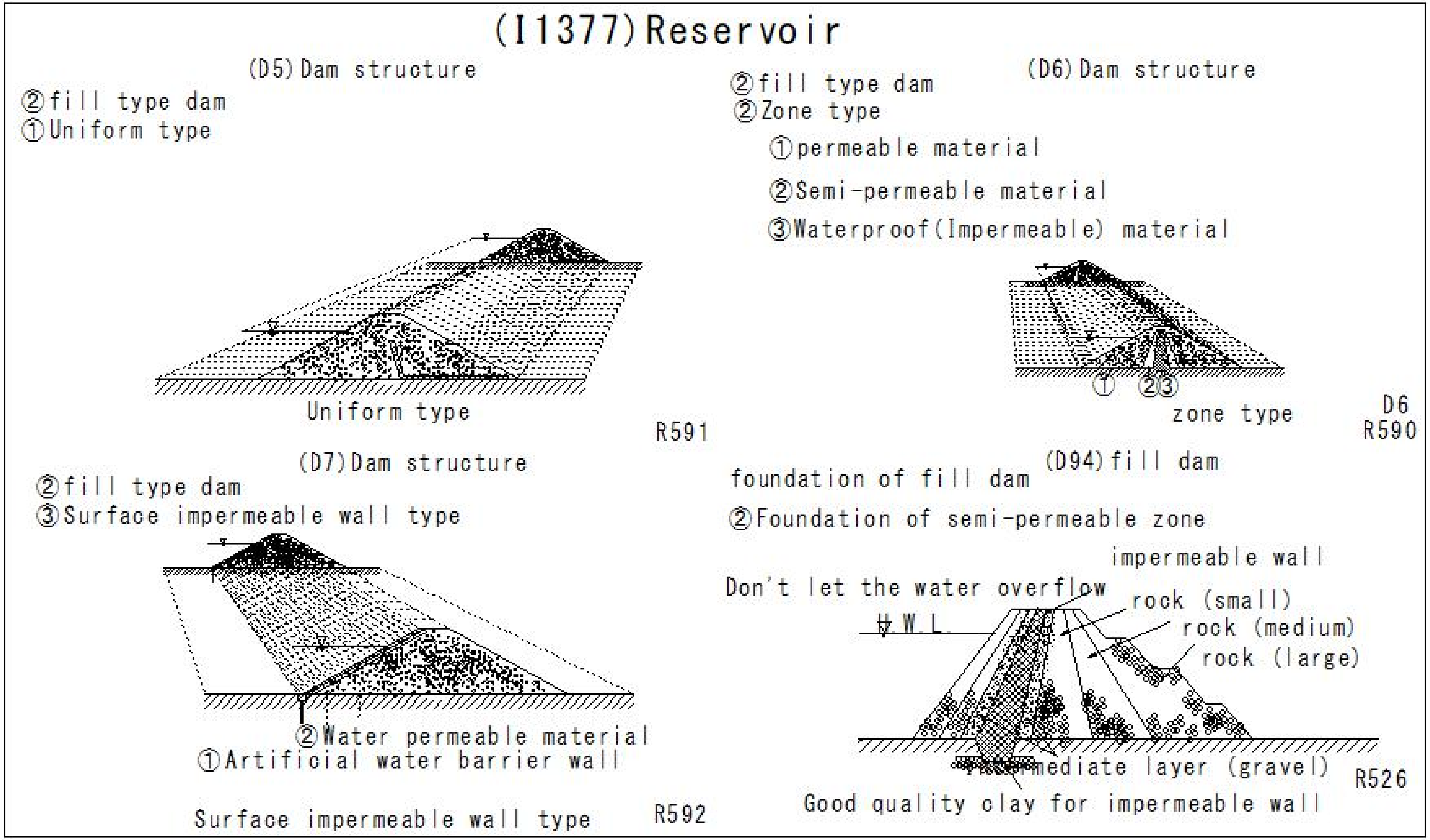
(I1375)Reservoir



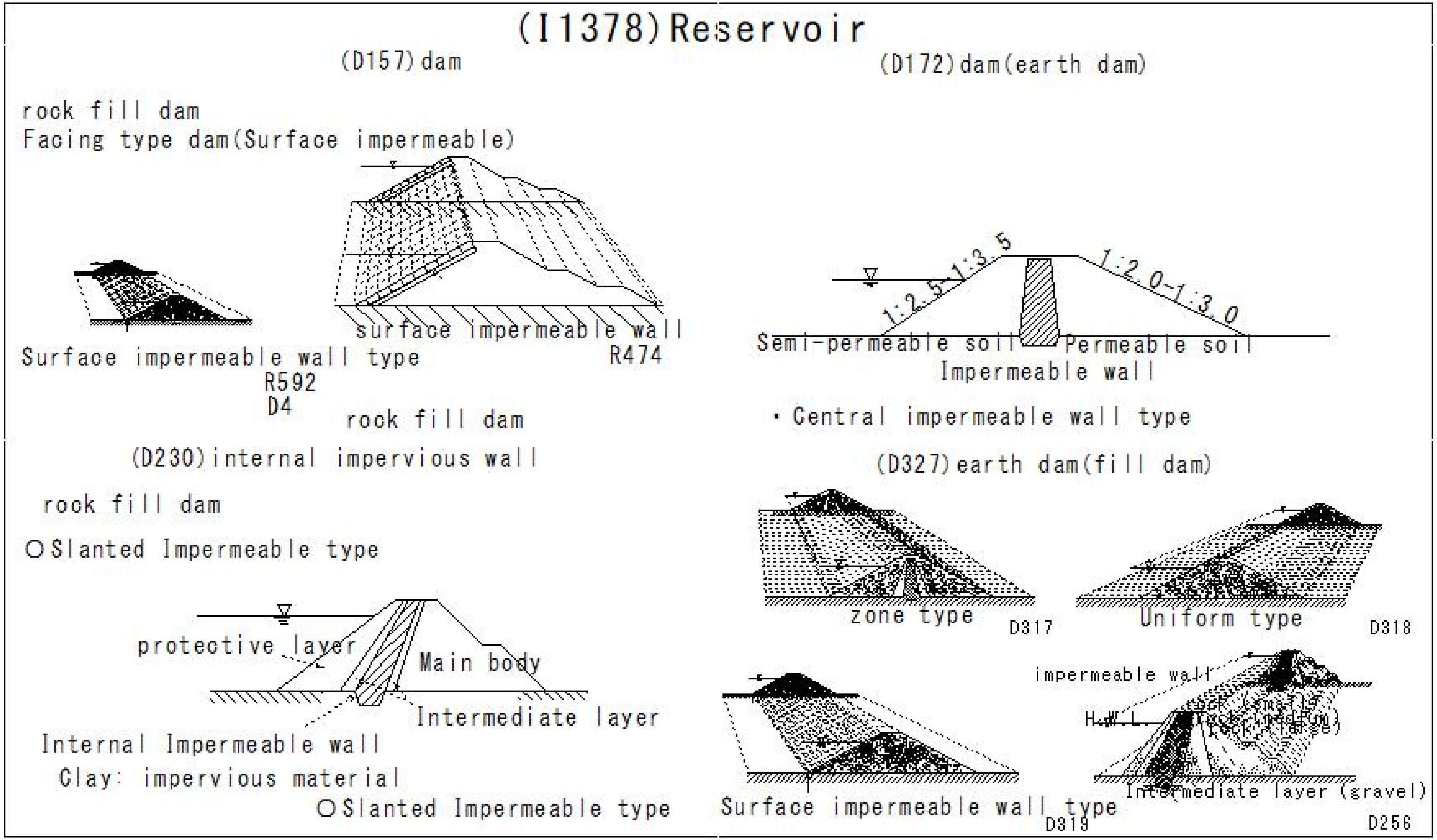
(I1376)Reservoir



(I1377)Reservoir



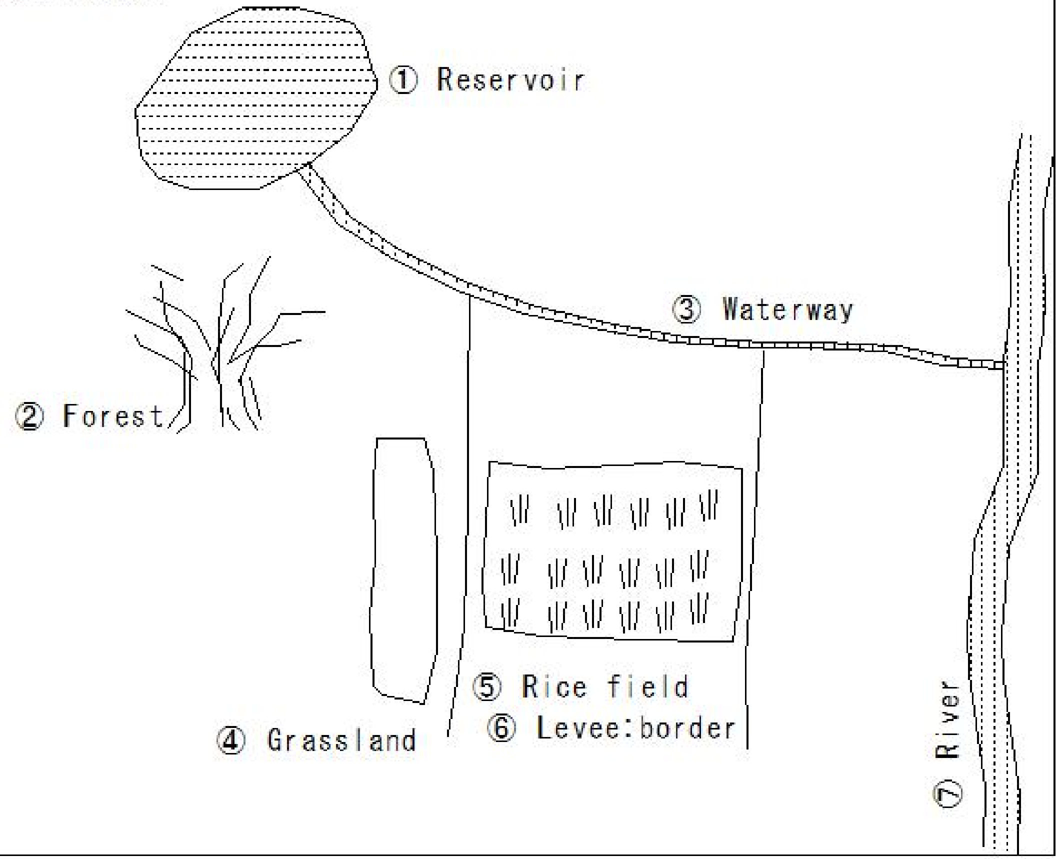
(I1378)Reservoir



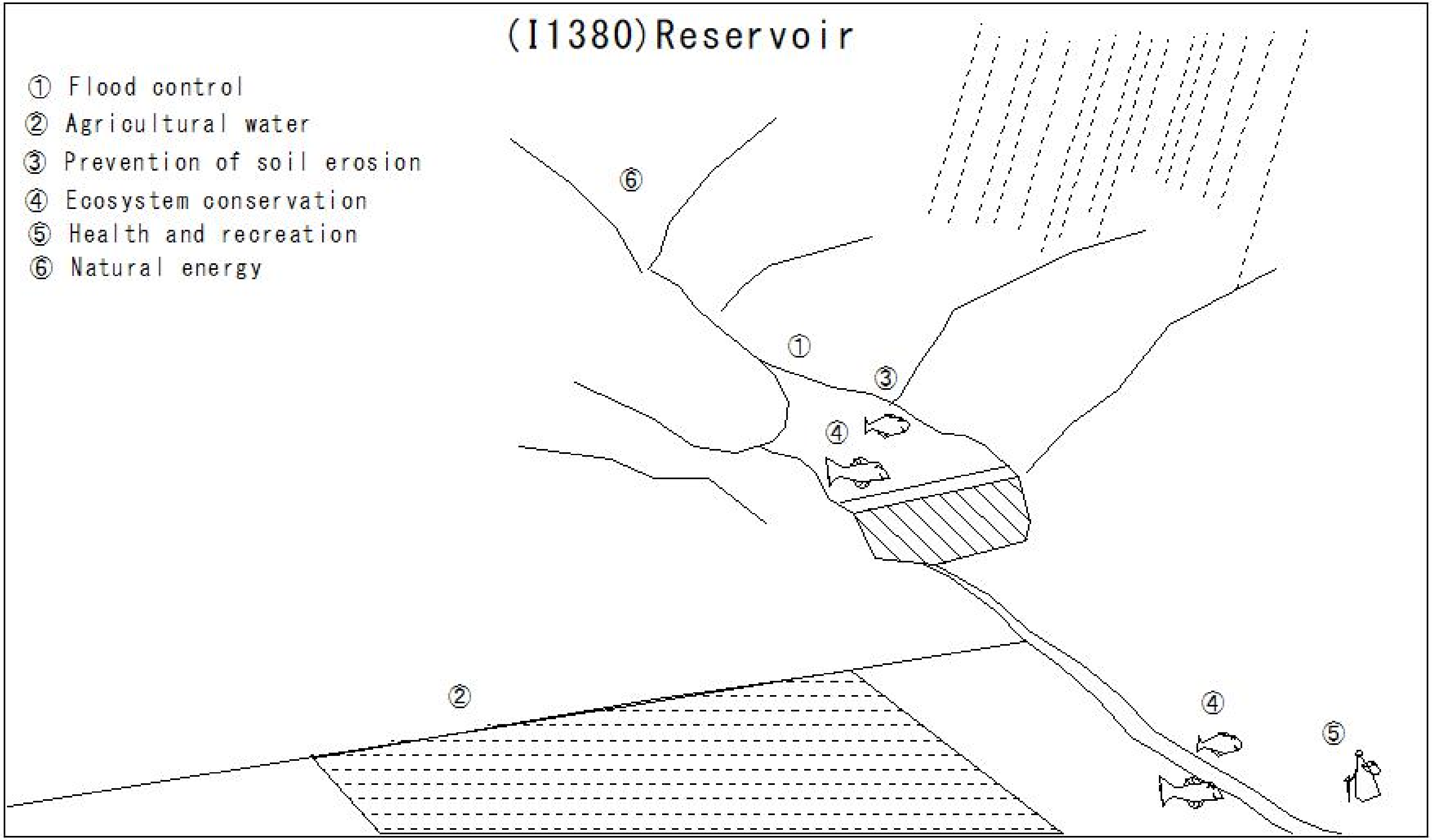
(I1379)Reservoir

(I1379)Reservoir

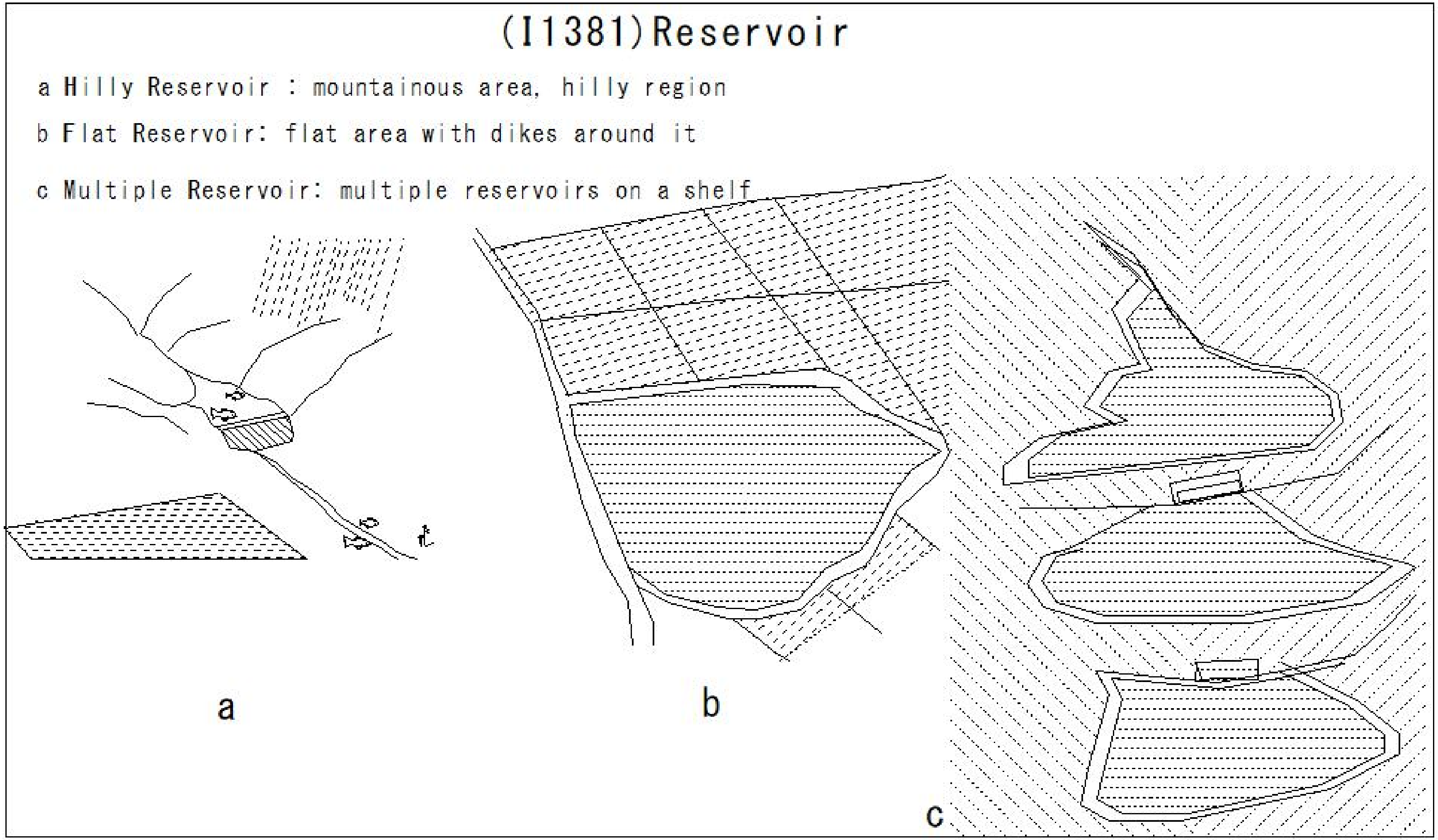
① In reservoir irrigation, water is stored in a reservoir
② Water is pumped to cultivated land when needed
③ Cultivate crops steadily



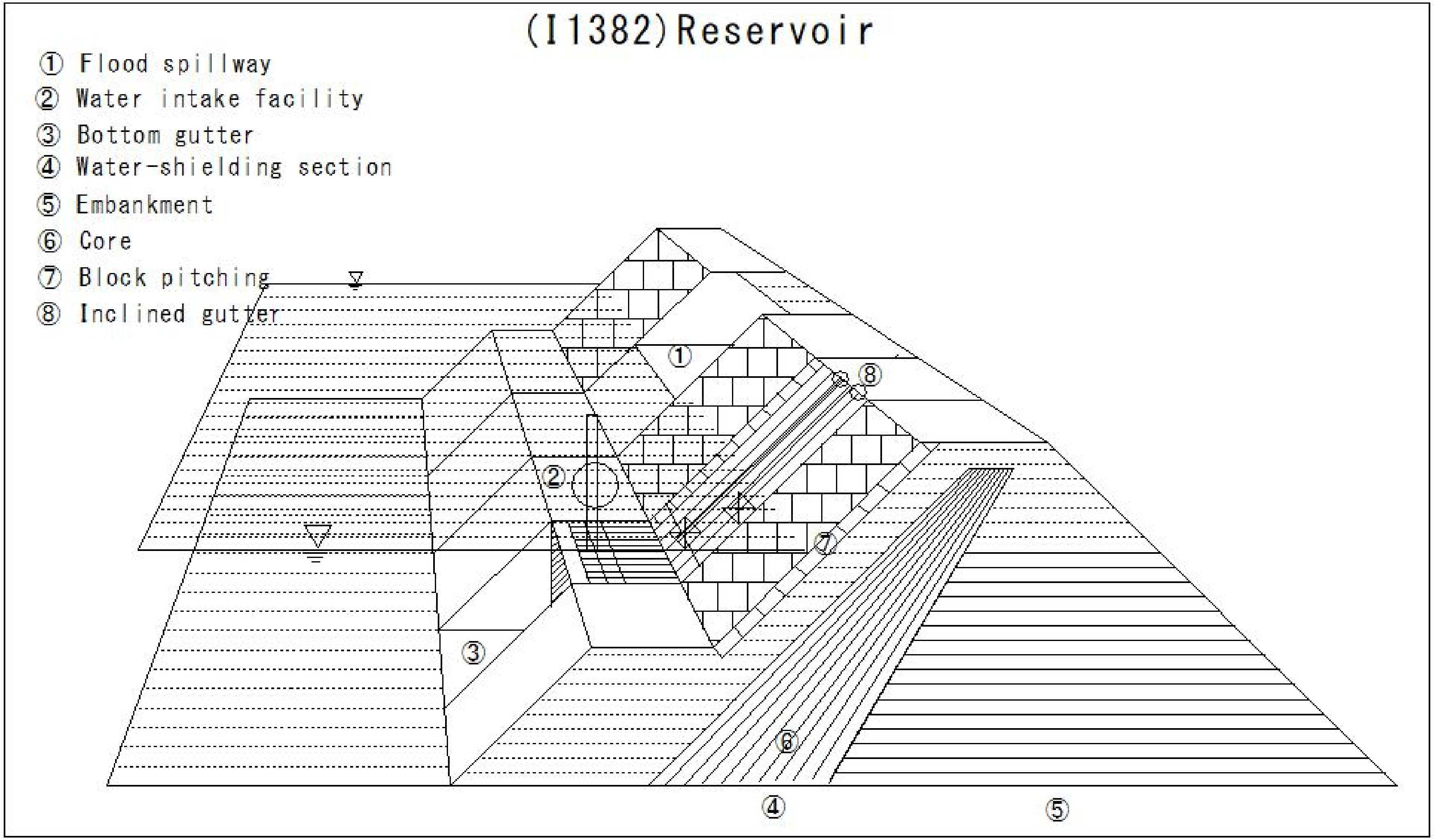
(I1380)Reservoir



(I1381)Reservoir



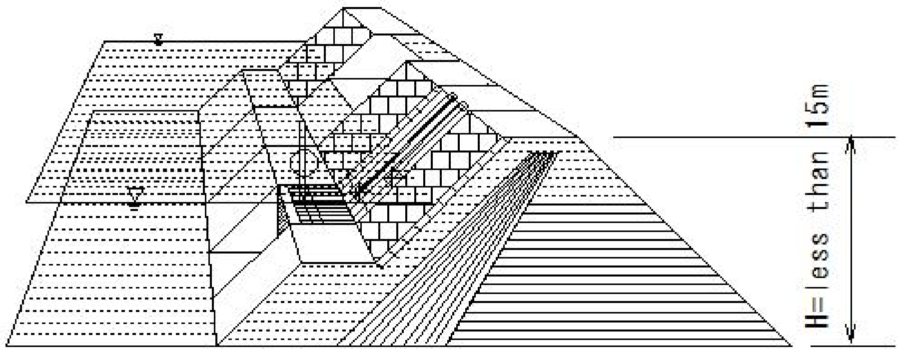
(I1382)Reservoir



(I1383)Reservoir

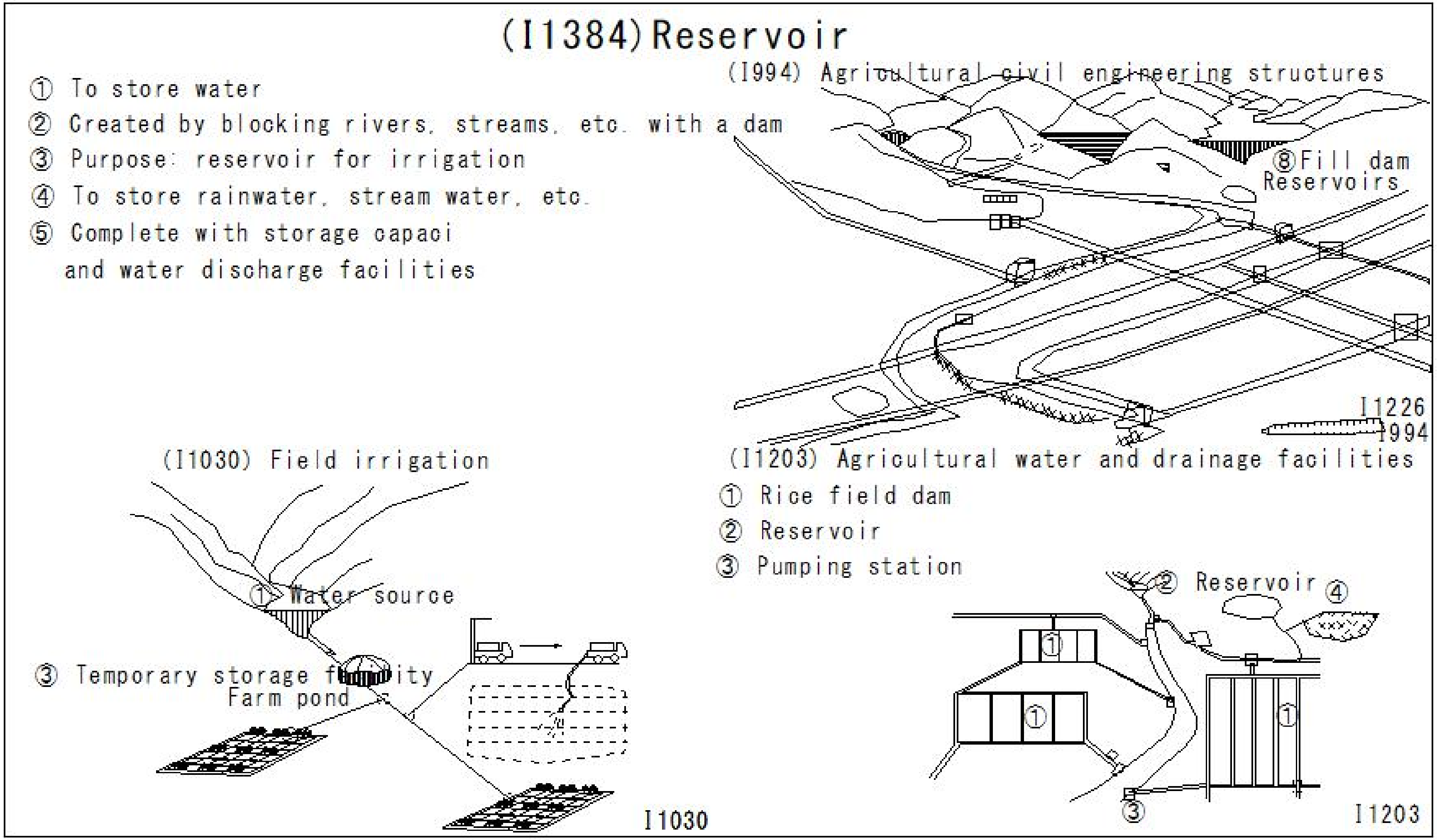
(I1383)Reservoir

Earthen embankments with a height (bank height) of less than 15m



Earthen embankments

(I1384)Reservoir



(I1385)Reservoir

(I1385)Reservoir

○Hilly Reservoir

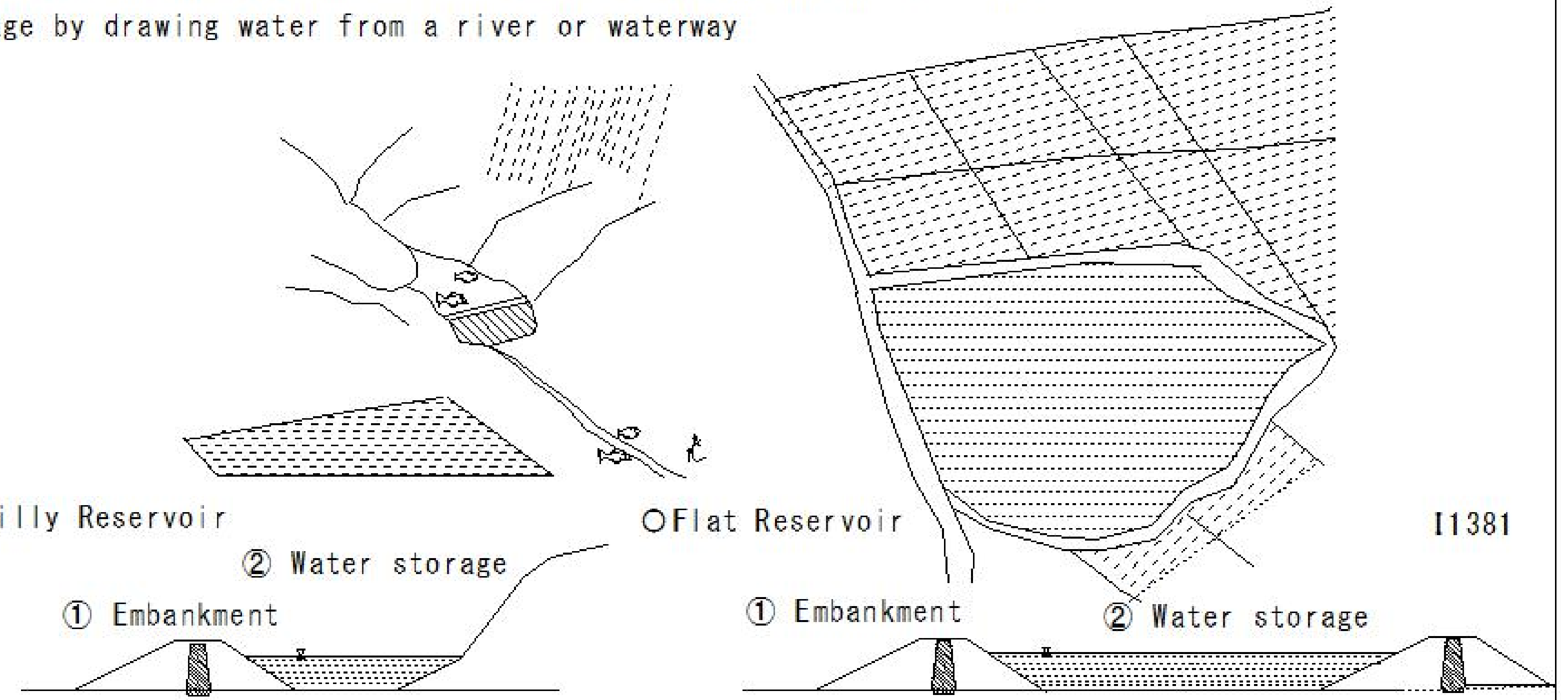
Reservoir made by damming a valley in mountainous or hilly areas

Storage by damming water flowing from the mountains

○Flat Reservoir

Reservoir made by building a levee around a depression on flat land

Storage by drawing water from a river or waterway



(I1386)Reservoir

(I1386)Reservoir

○ Structure of the reservoir

① Spillway

② Embankment

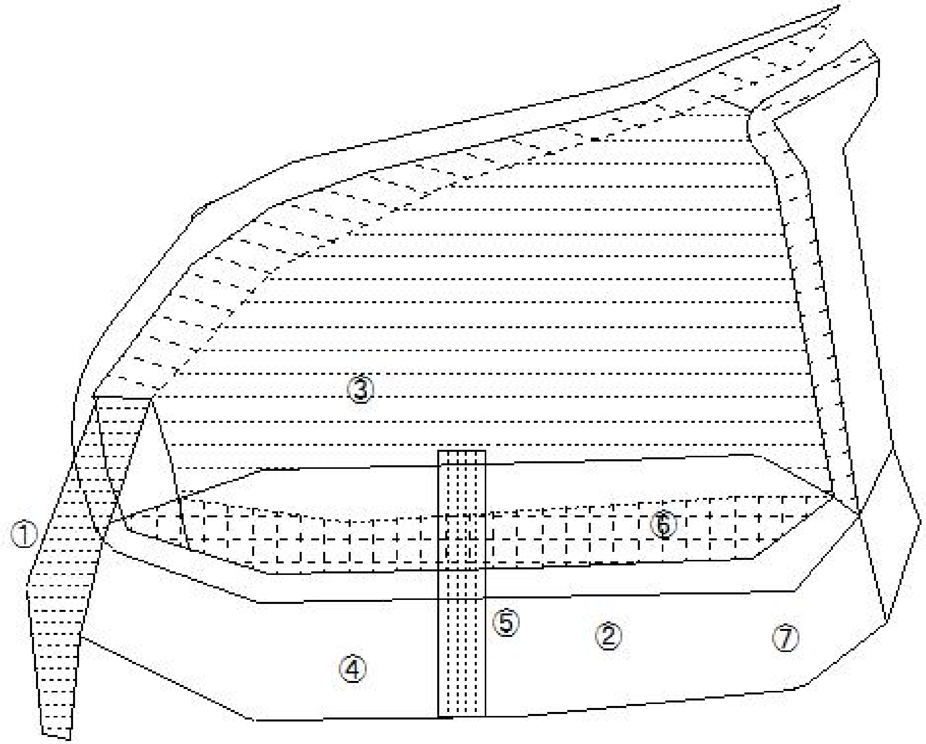
③ Upstream side of embankment

④ Downstream side of embankment

⑤ Water intake facility

⑥ Block pitching

⑦ Embankment



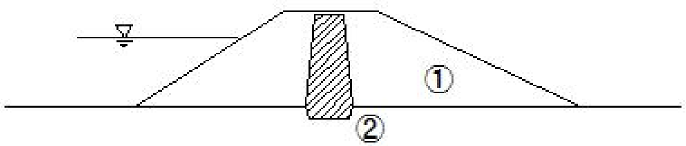
(I1387)Reservoir

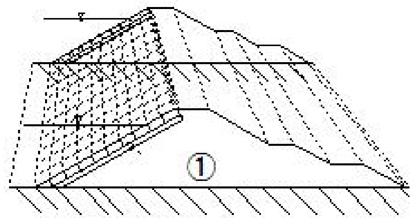
(I1387)Reservoir

○ Embankment body

① Clay soil - tamping

② Core - Clay soil that is difficult for water to pass through





Fill type dam

I1376

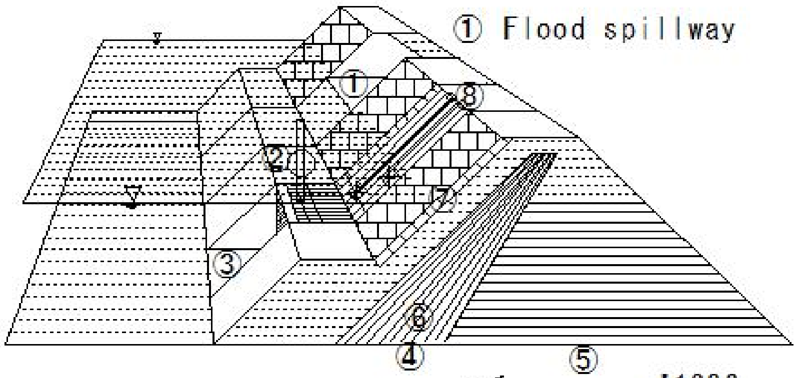
(I1388)Reservoir

(I1388)Reservoir

○ Flood spillway (spillway)

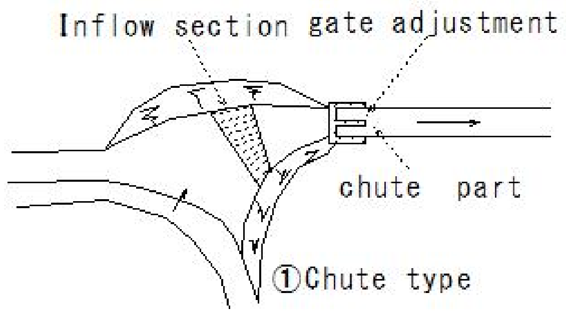
① A facility that prevents water from overflowing the embankment during heavy rains

② A facility that safely drains water flowing into a reservoir

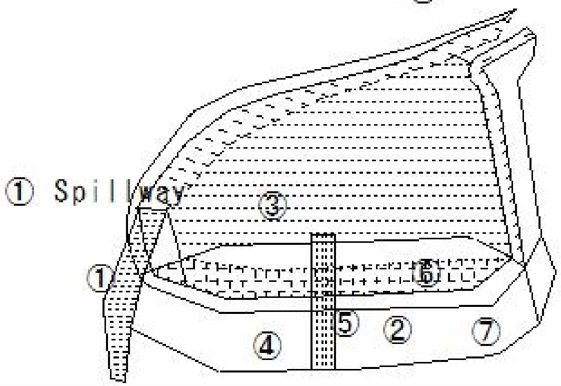


I1382

○ Flood spillway (spillway)

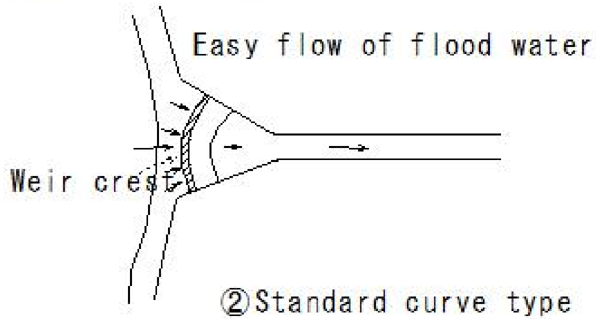


D303



I1386

flood sluice of fill dam



D304

(I1389)Reservoir

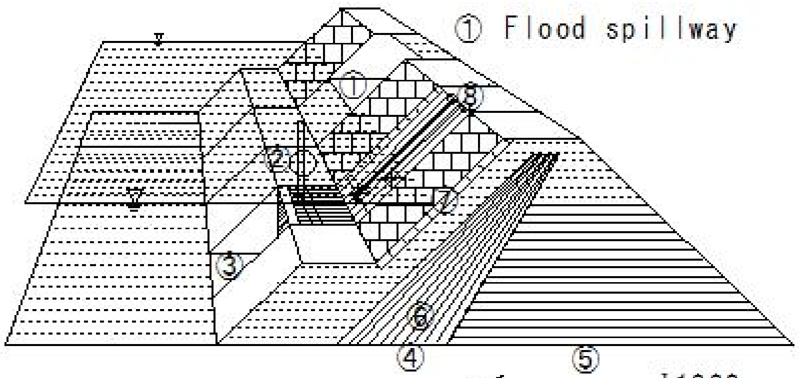
(I1389)Reservoir

○ Flood spillway (spillway)

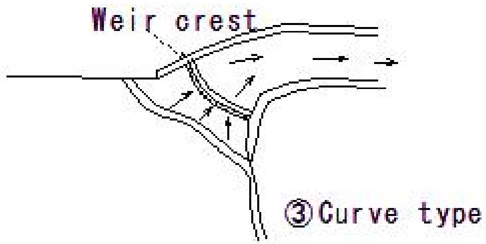
① A facility that prevents water from overflowing the embankment during heavy rains

② A facility that safely drains water flowing into a reservoir

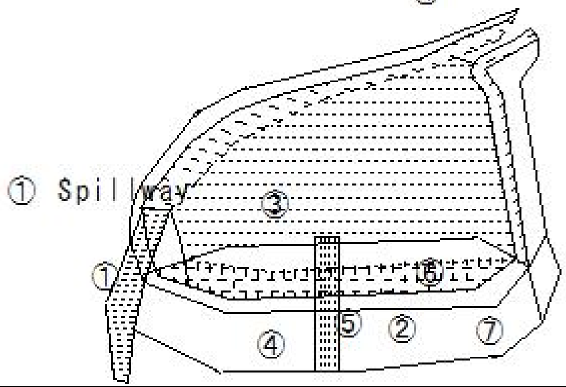
○ Flood spillway (spillway)



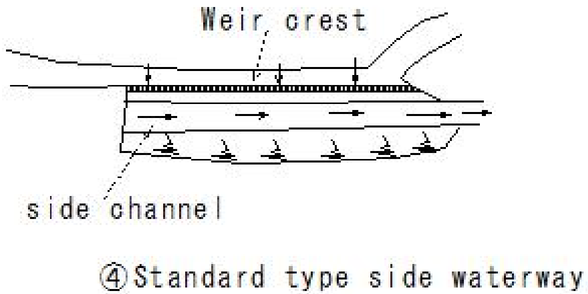
I1382



D305



I1386



D306

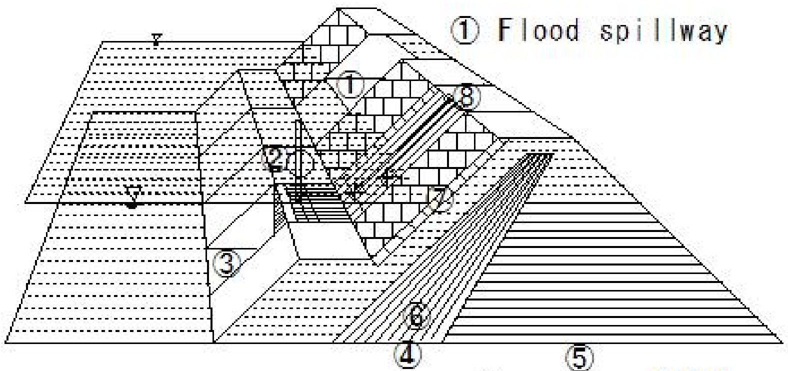
(I1390)Reservoir

(I1390)Reservoir

○ Flood spillway (spillway)

① A facility that prevents water from overflowing the embankment during heavy rains

② A facility that safely drains water flowing into a reservoir



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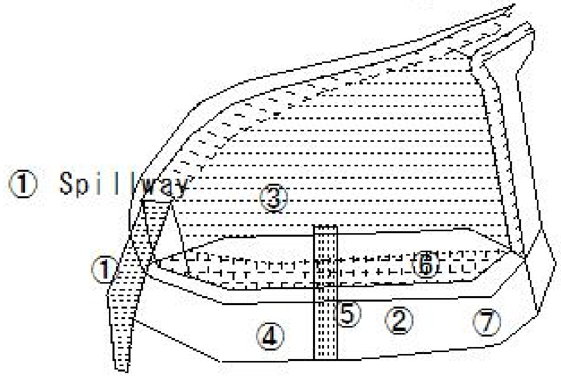
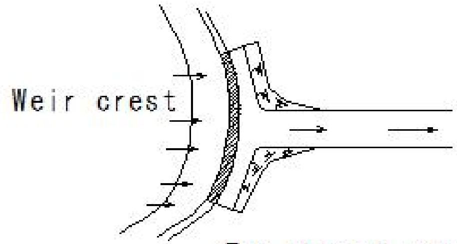


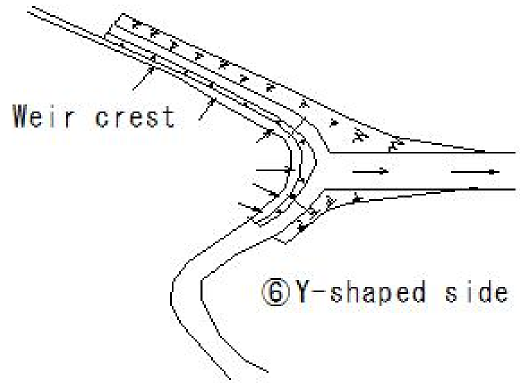
I1386

○ Flood spillway (spillway)



⑤T-shaped side waterway

D307



⑥Y-shaped side waterway

D308

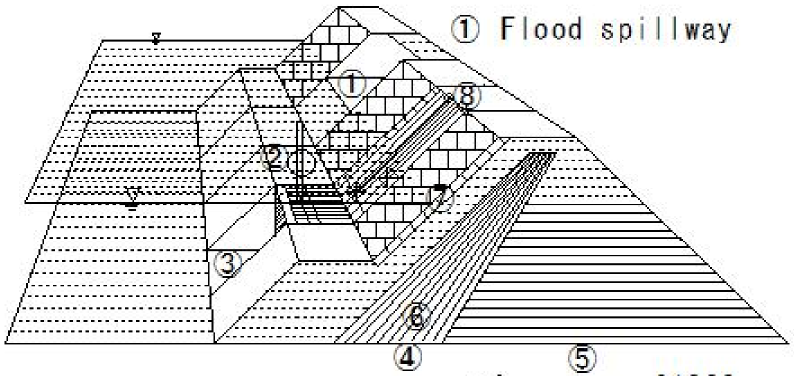
(I1391)Reservoir

(I1391)Reservoir

○ Flood spillway (spillway)

① A facility that prevents water from overflowing the embankment during heavy rains

② A facility that safely drains water flowing into a reservoir



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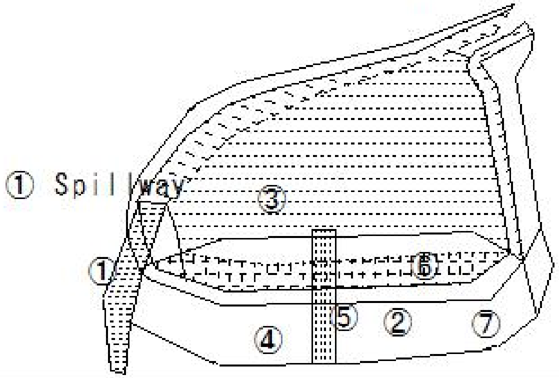
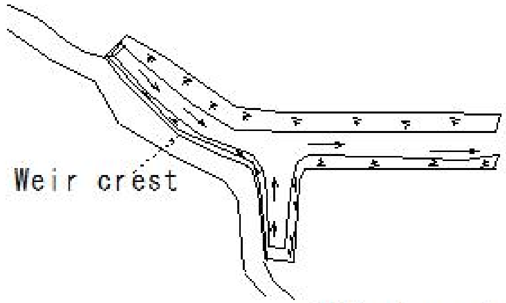


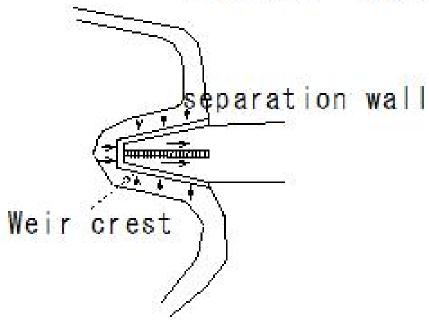
I1386

○ Flood spillway (spillway)



⑦Contour type side channel

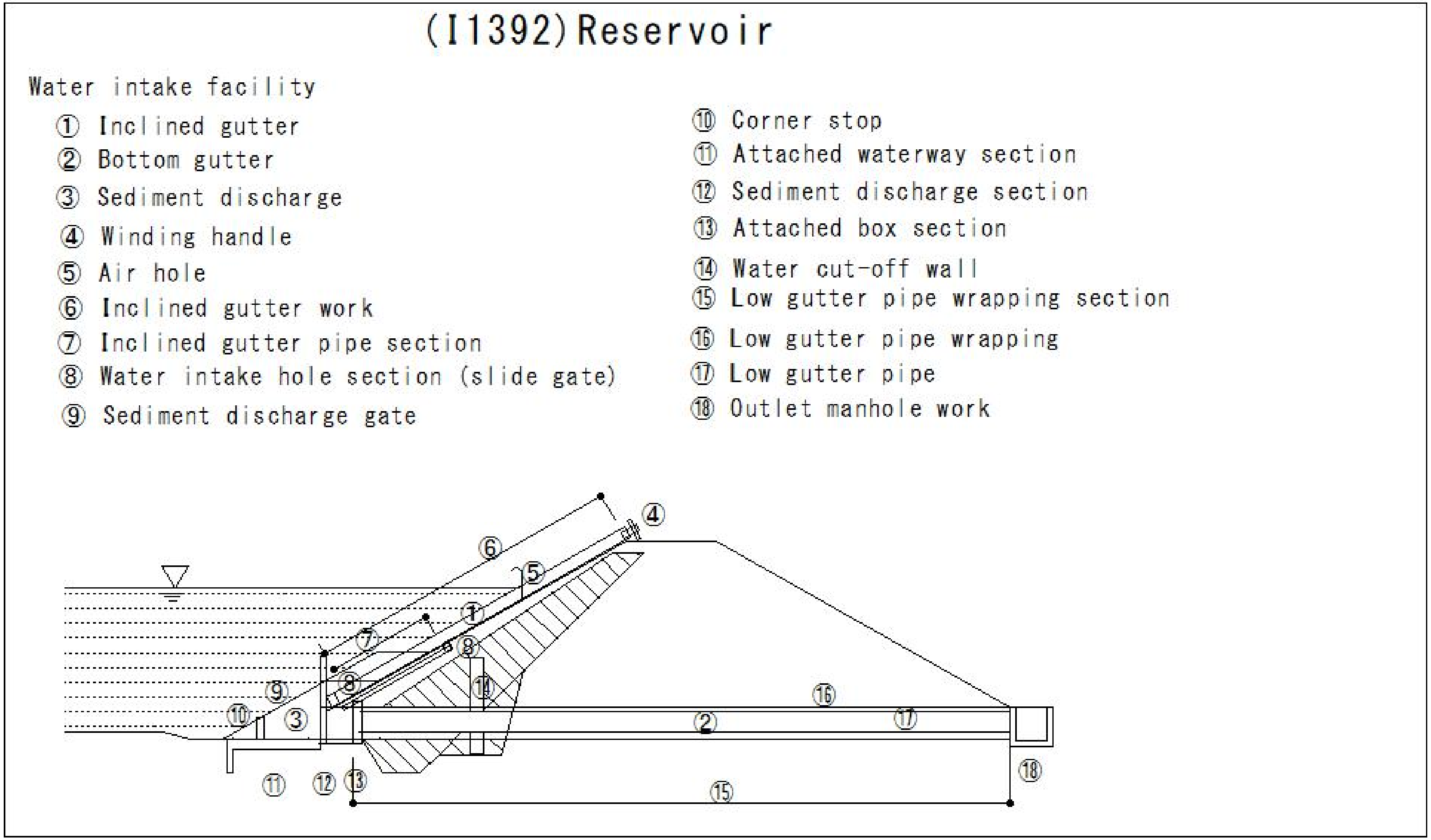
D309



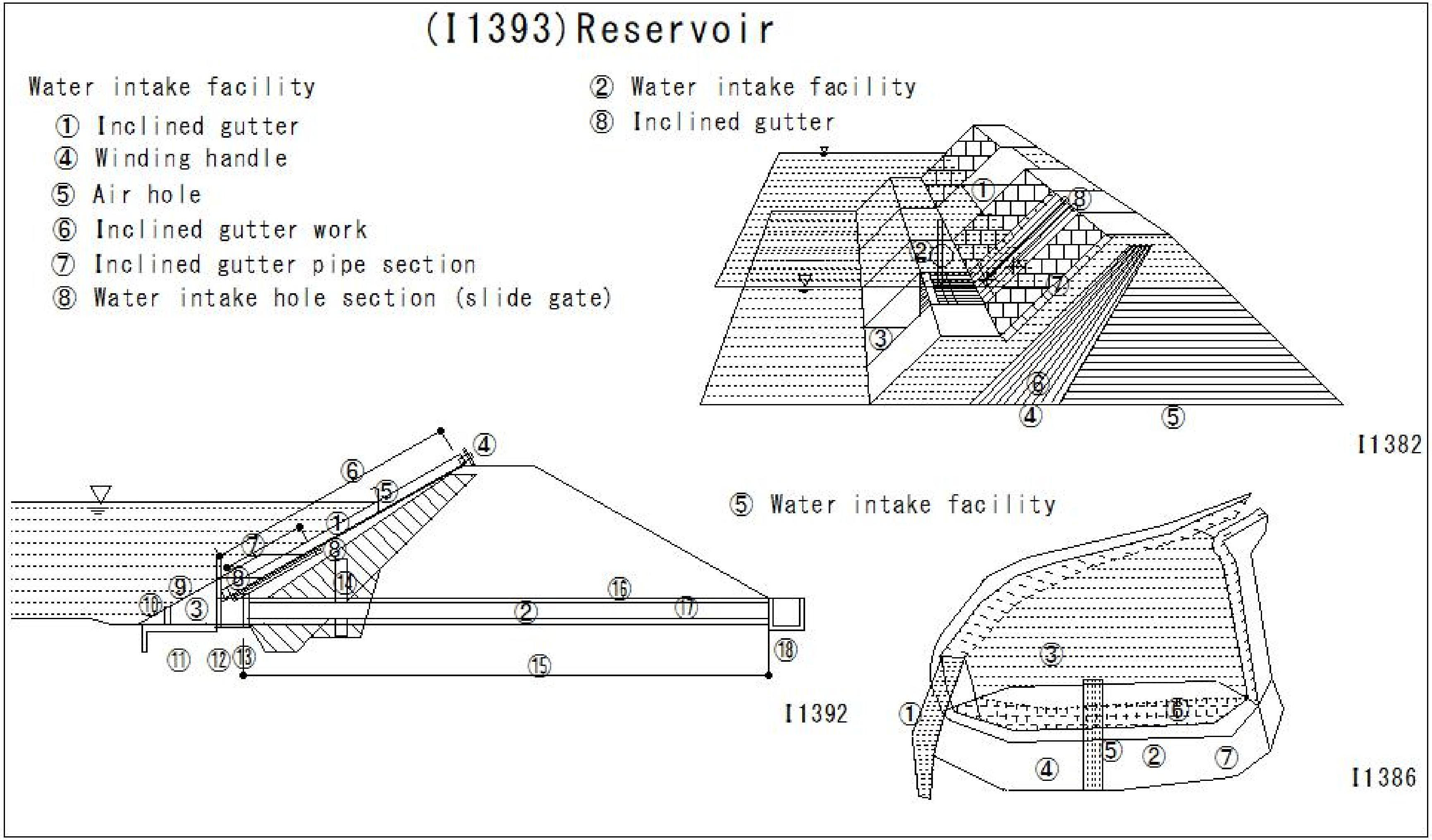
⑨Bathtub type

D311

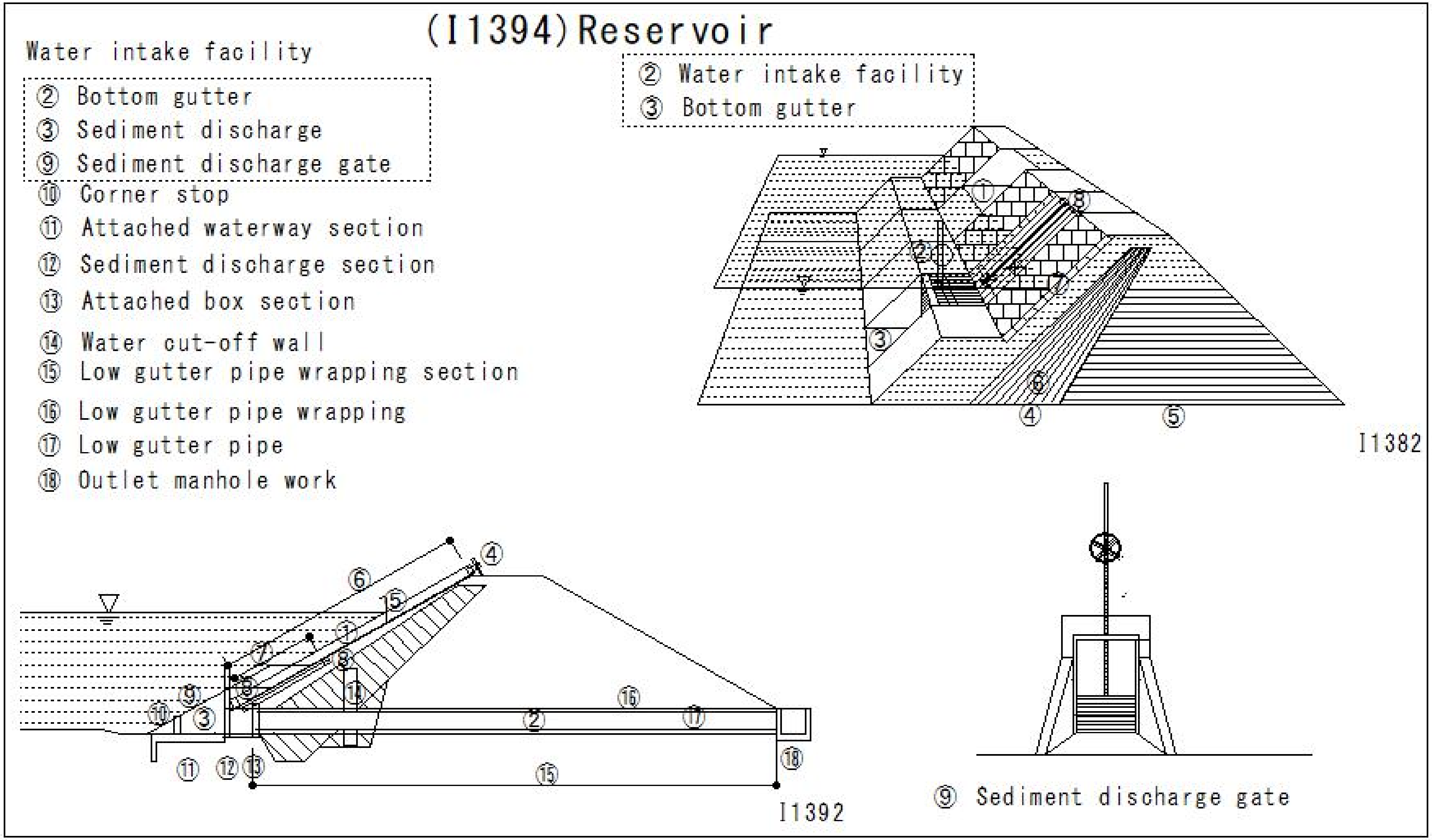
(I1392)Reservoir



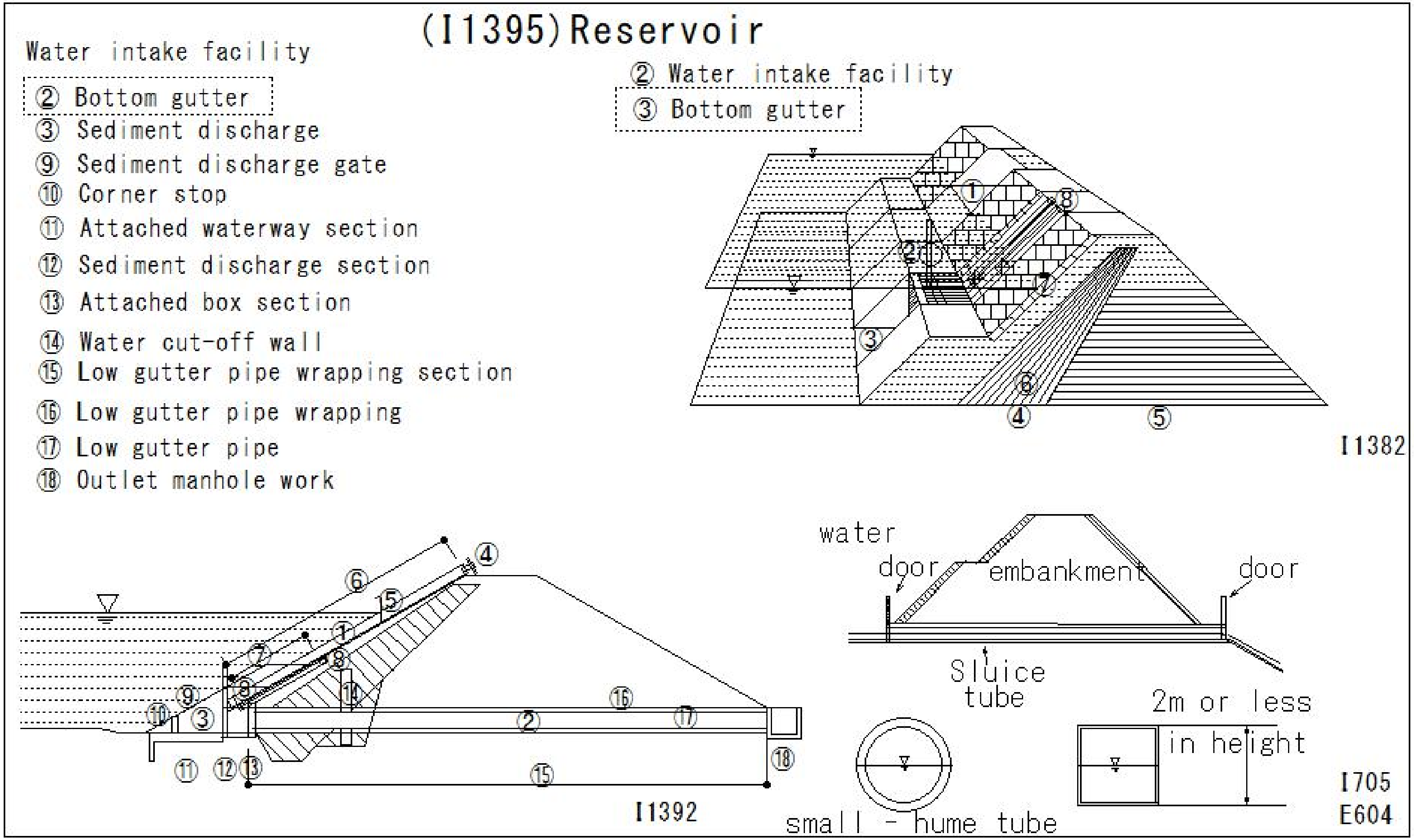
(I1393)Reservoir



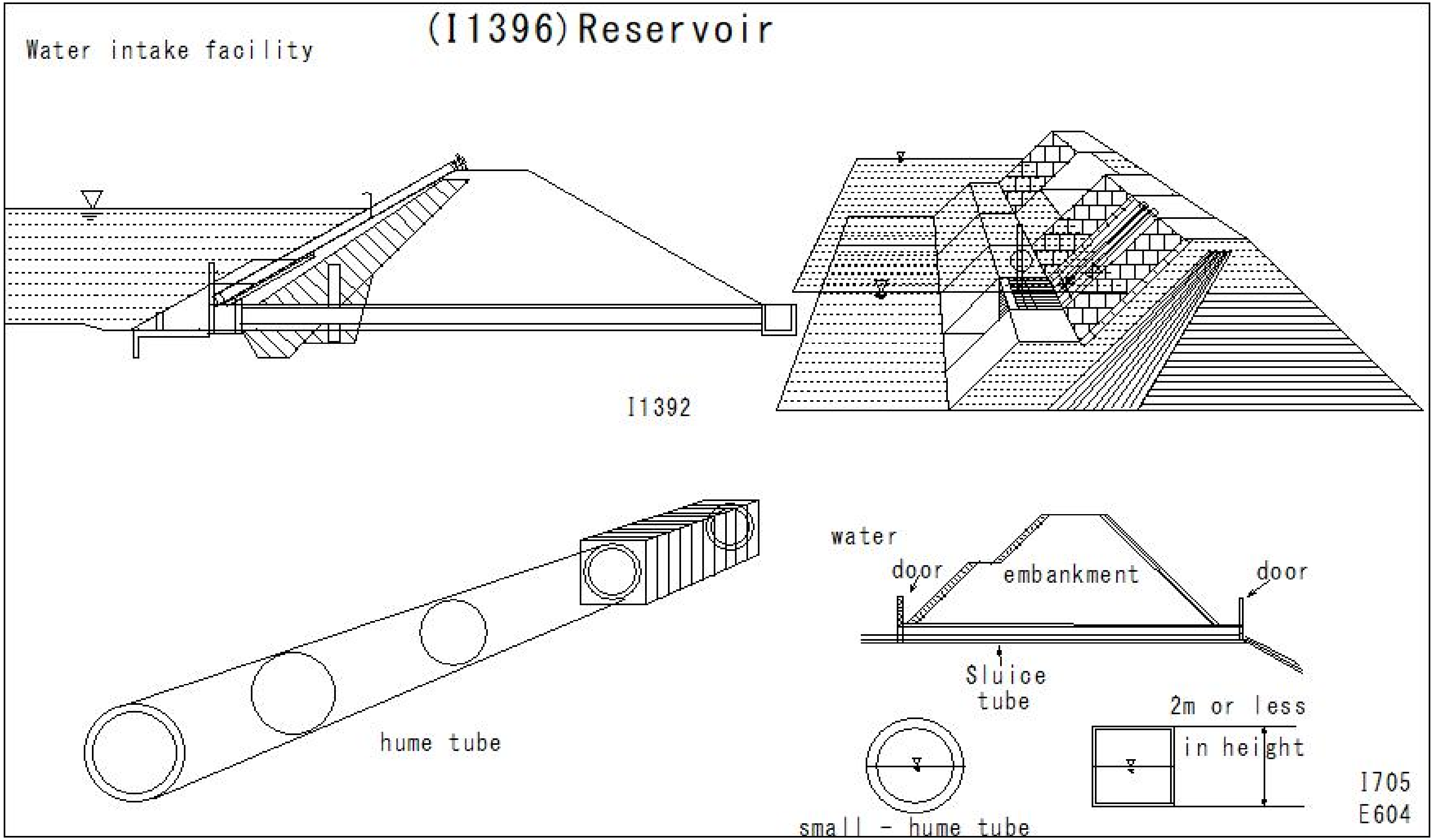
(I1394)Reservoir



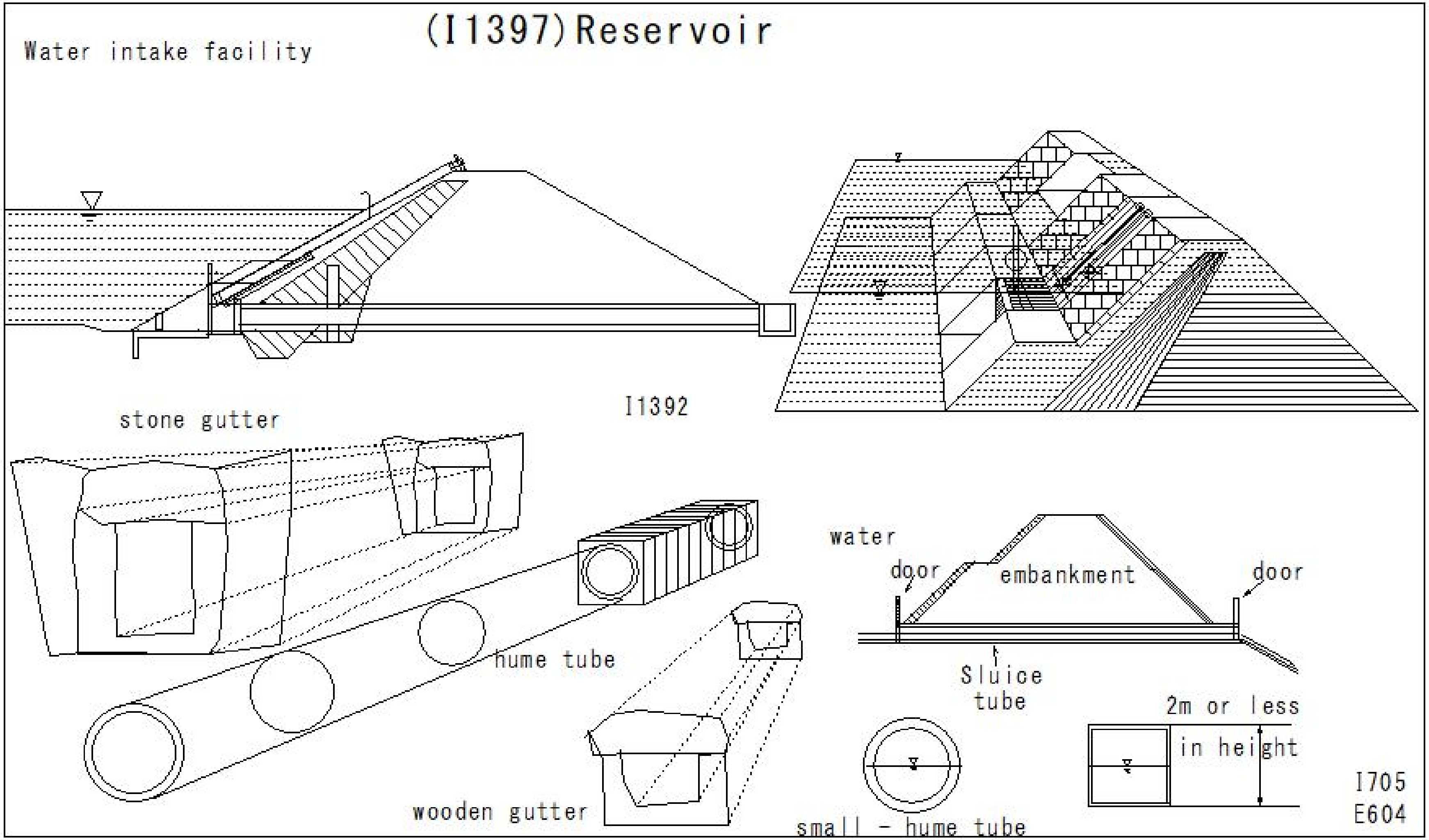
(I1395)Reservoir



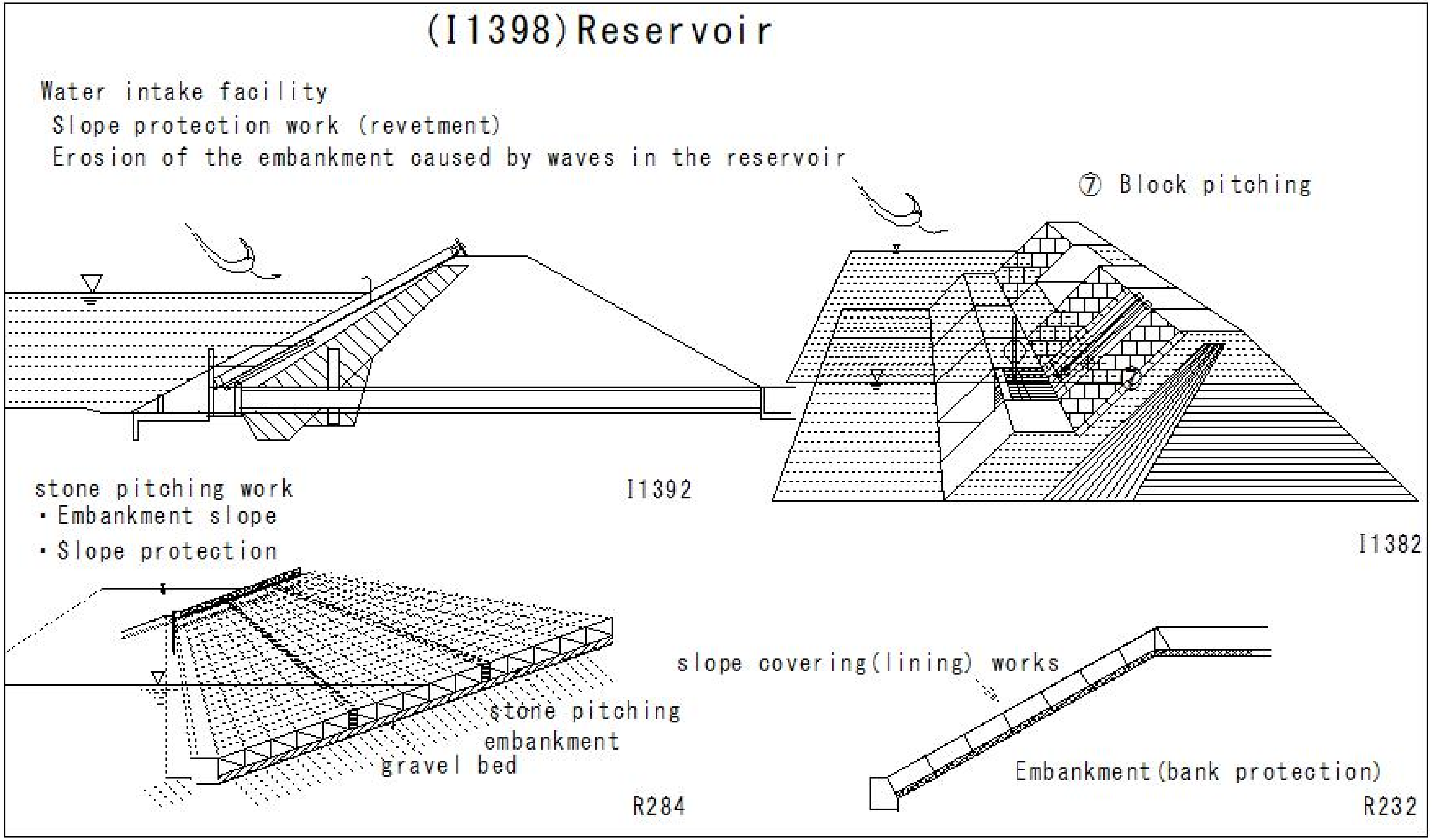
(I1396)Reservoir



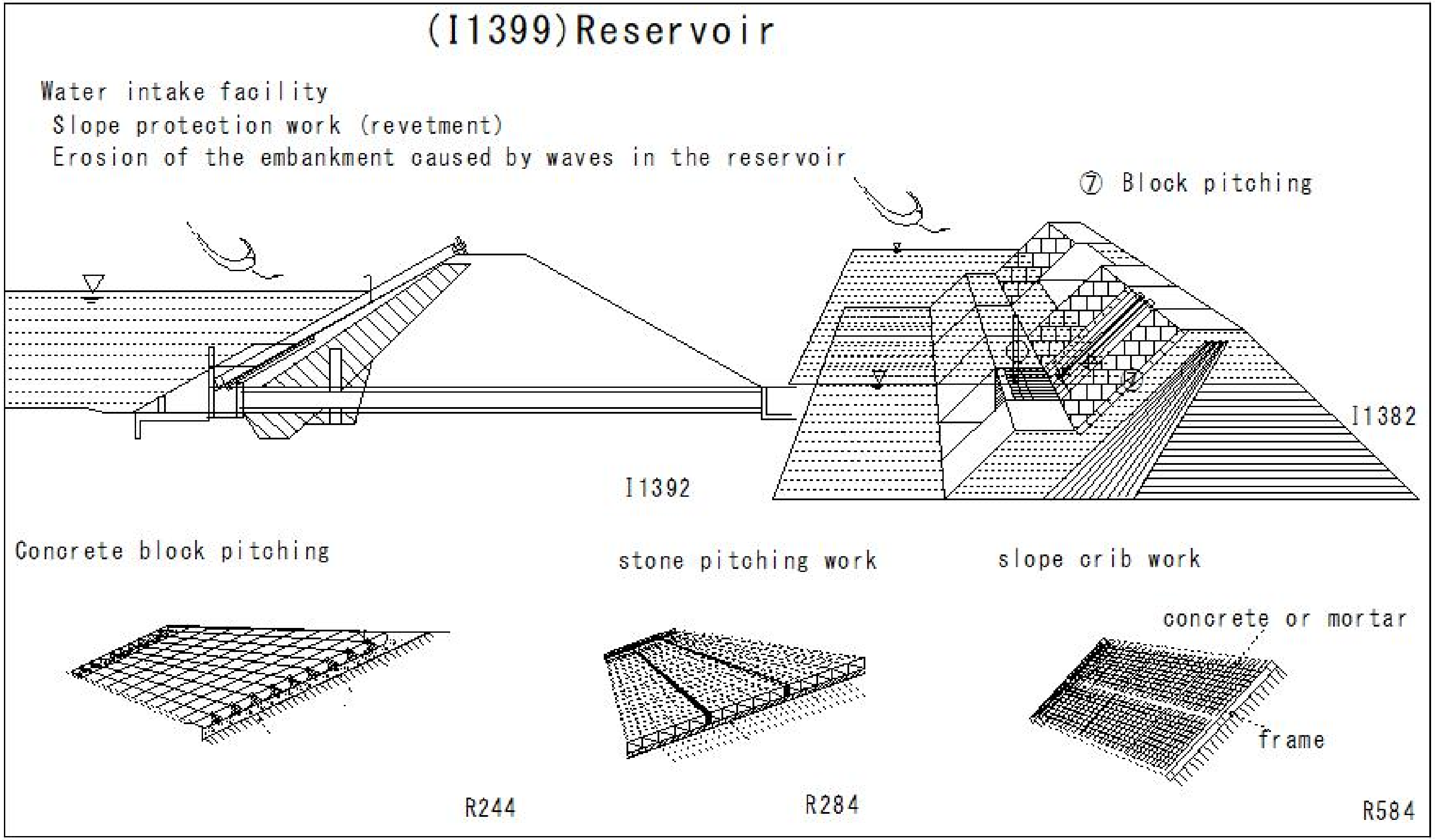
(I1397)Reservoir



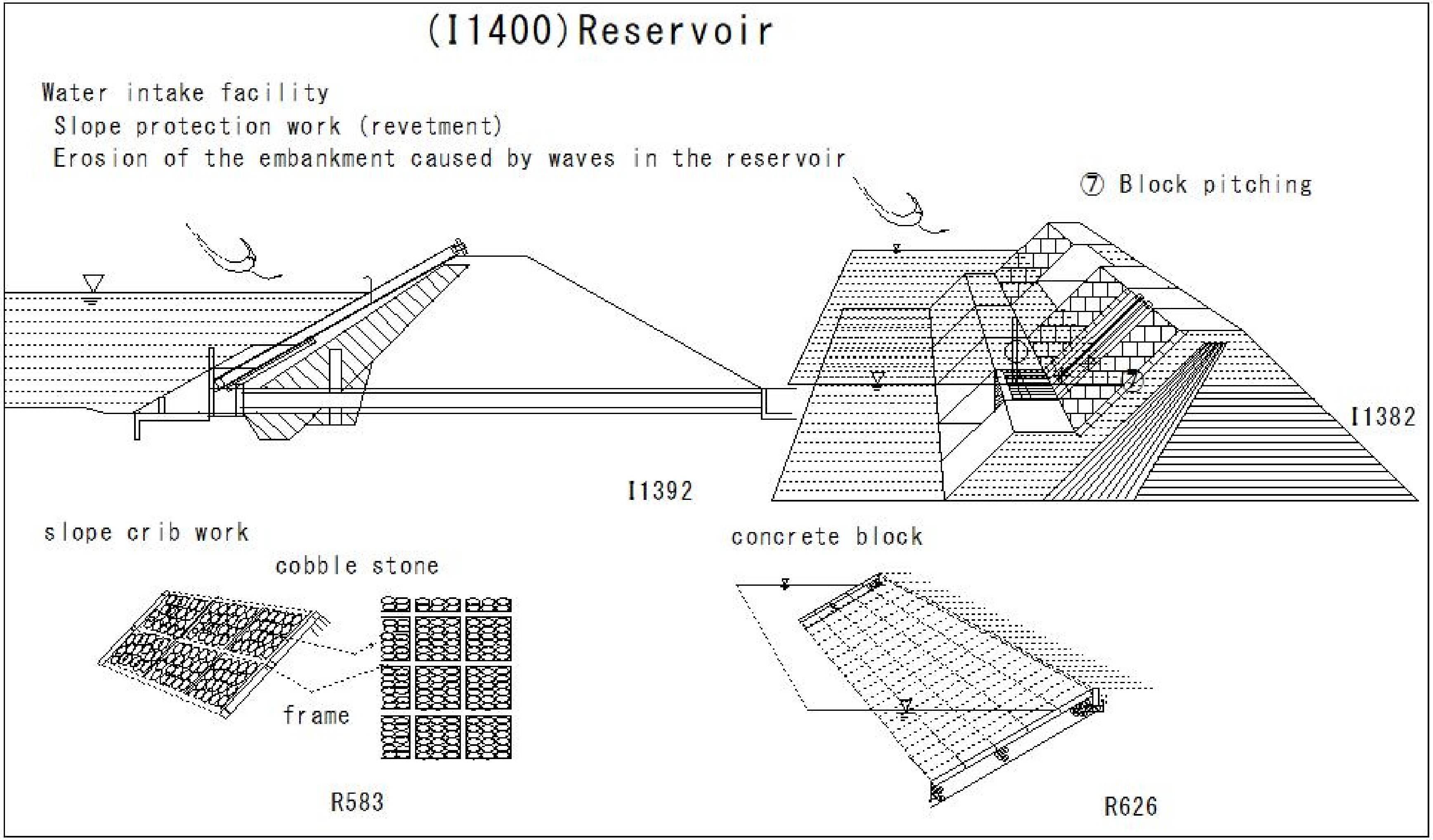
(I1398)Reservoir



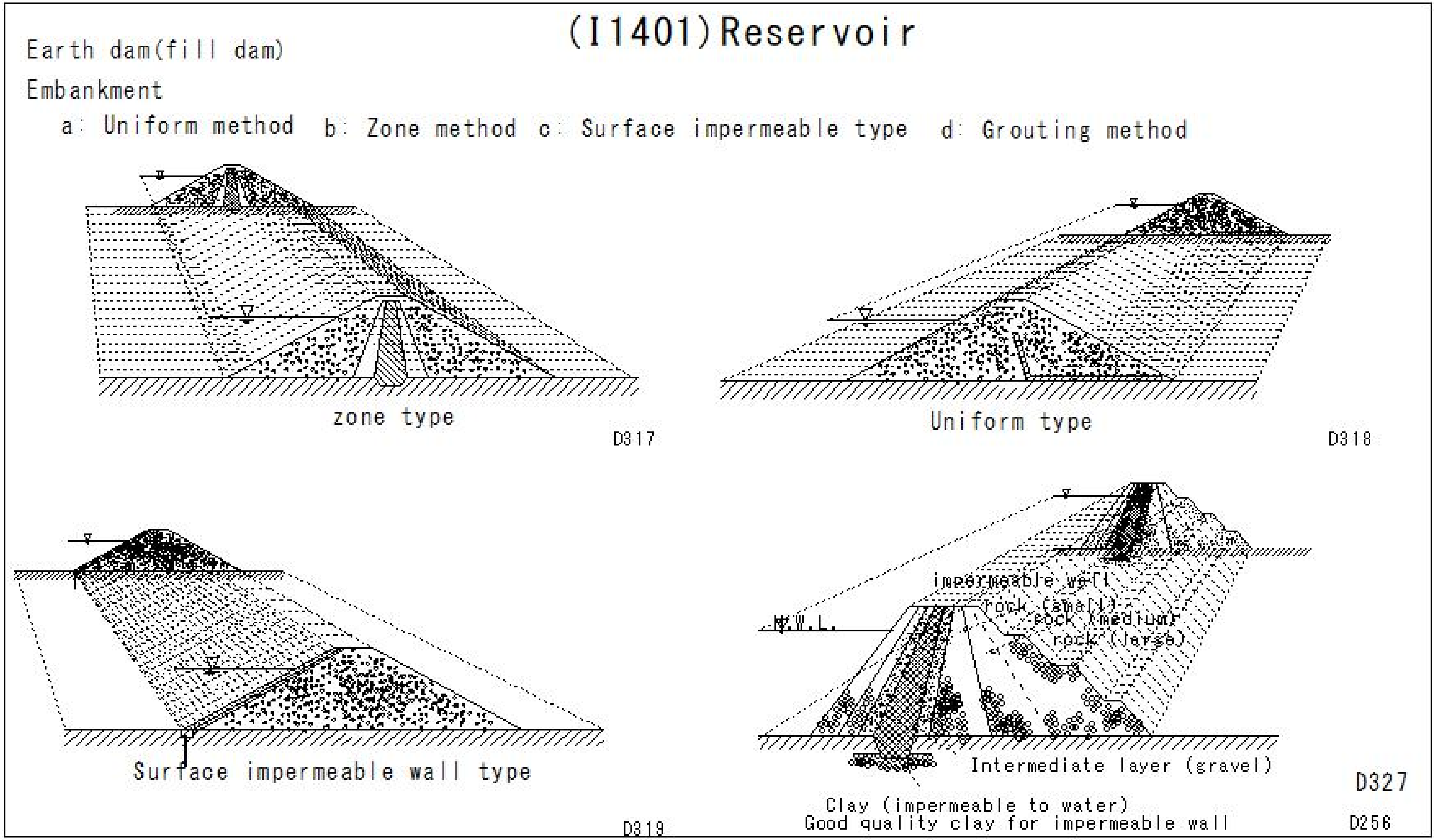
(I1399)Reservoir



(I1400)Reservoir



(I1401)Reservoir



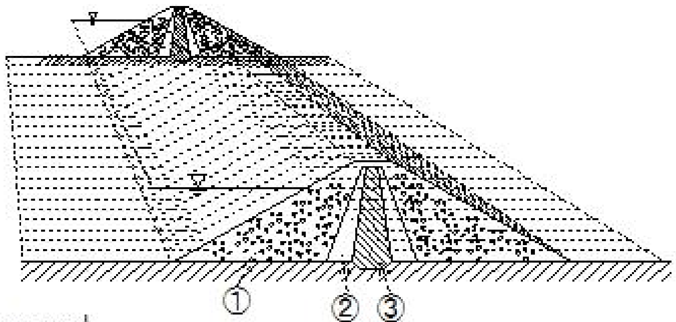
(I1402)Reservoir

(I1402)Reservoir

②fill type dam
②Zone type

①permeable material
②Semi-permeable material
③Waterproof(Impermeable) material

spillway installed on the ground



zone type

D6
R590

(I1403)Reservoir

(I1403)Reservoir

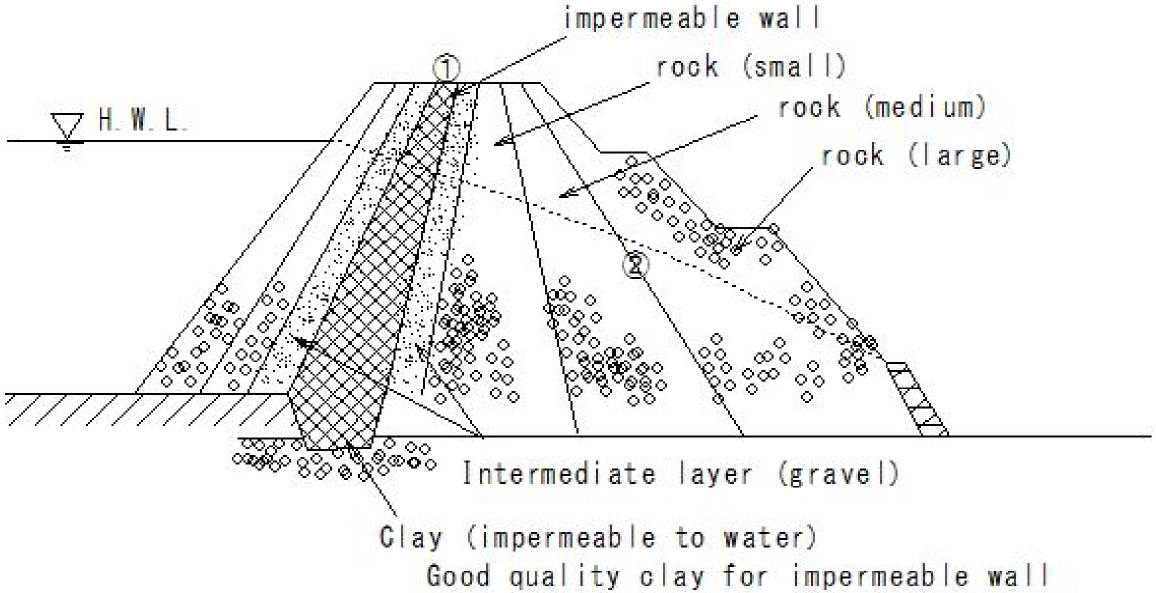
Fill type dam

Zone type

- 90% of the reservoir

①Impermeable zone

②Infiltration line



D111
R526

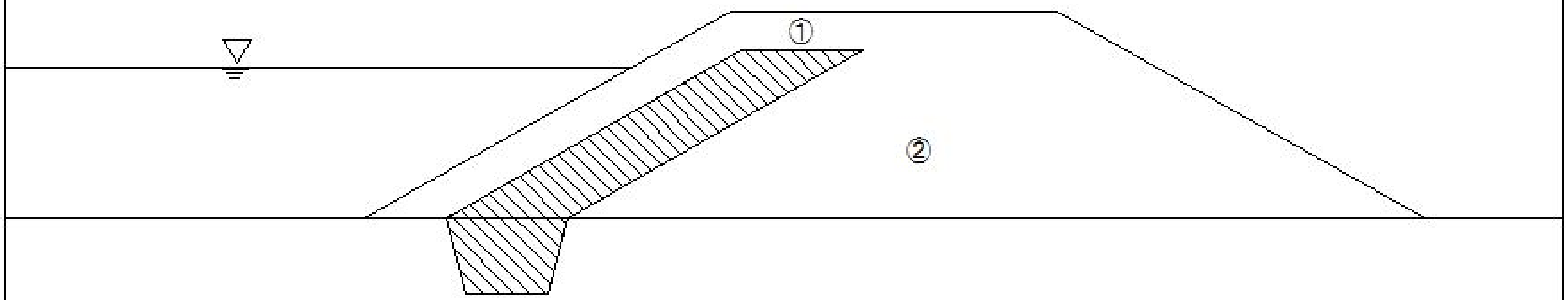
(I1404)Reservoir

(I1404)Reservoir

Embankment repair

①Water-impermeable material (clay soil)
Permeability coefficient K1<1×105cm/s

②Random material K2<10×k1



(I1405)Reservoir

(I1405)Reservoir

Embankment repair

a Water-proofing material (clay soil)

Ensuring watertightness of the embankment

b Excavation of trench

Cause of water leakage due to poor construction

Digging down to foundation ground

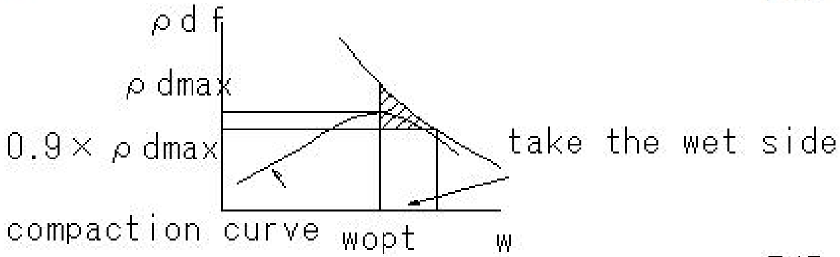
c Compaction

Compact with optimal moisture content

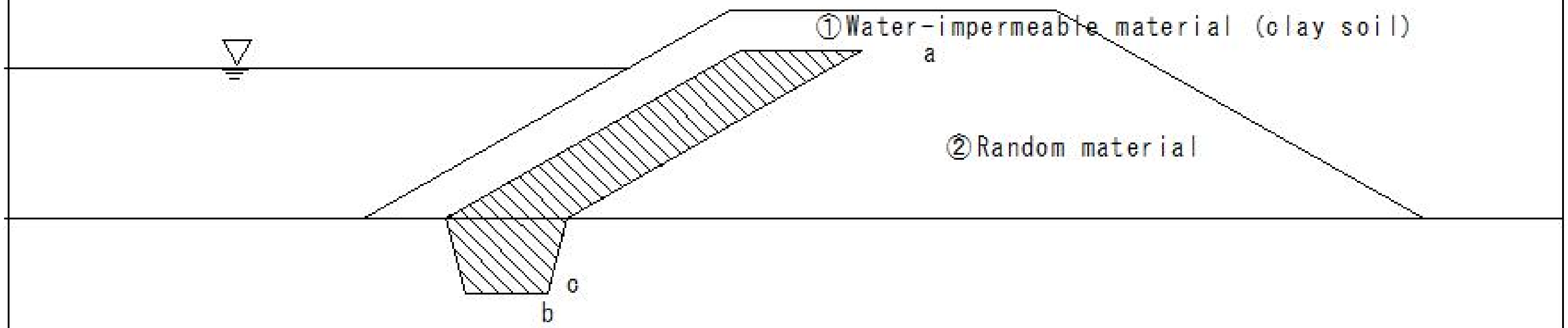
Adjust moisture content using quicklime, etc.

E82

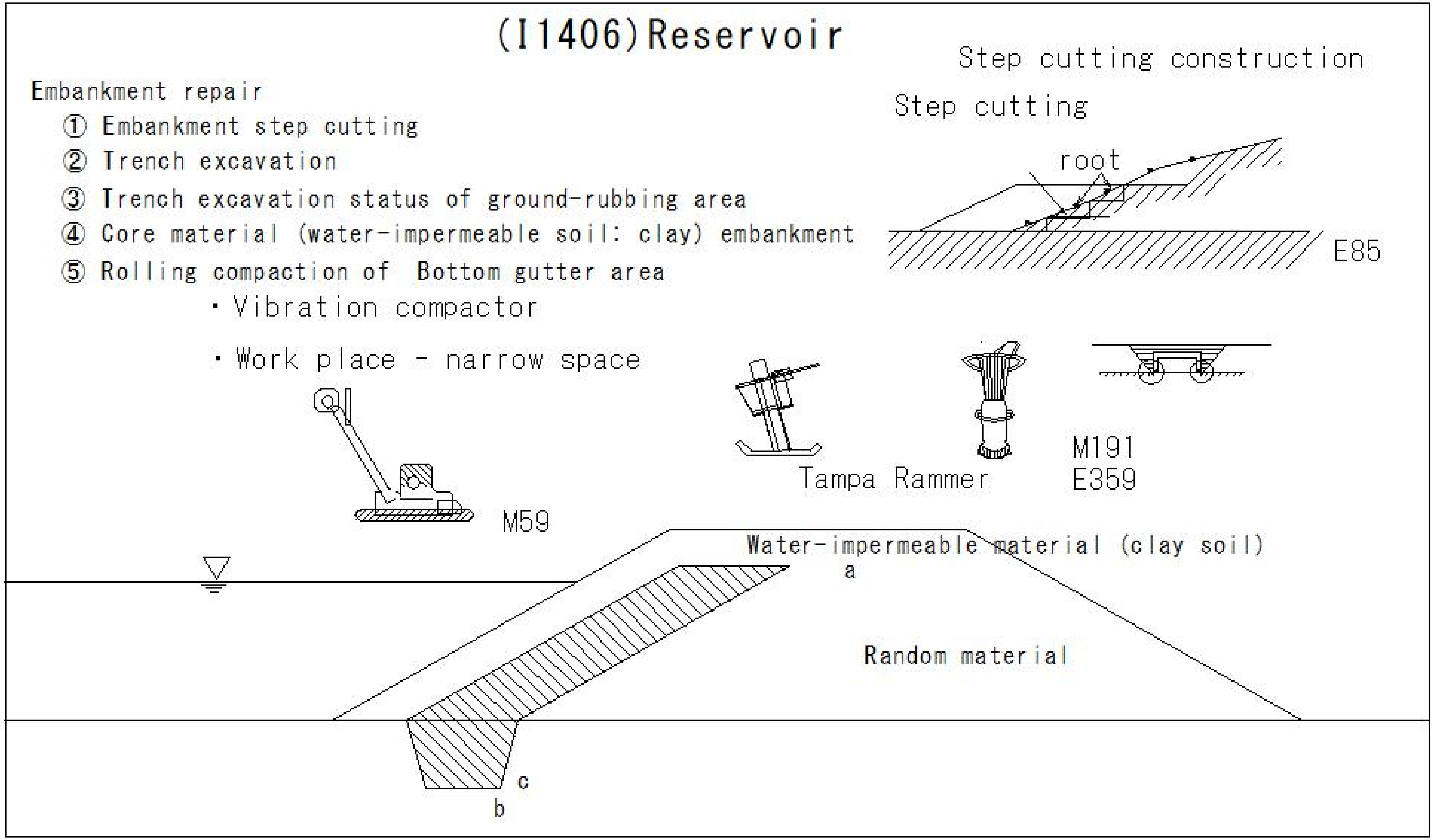
D109



E45



(I1406)Reservoir



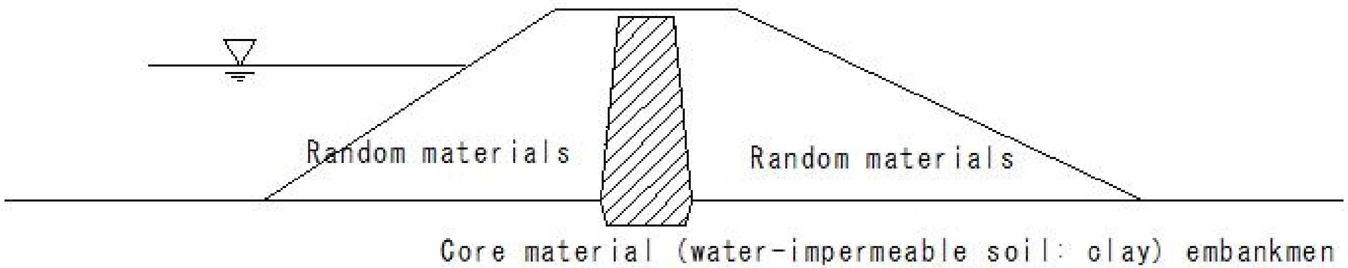
(I1407)Reservoir

(I1407)Reservoir

○ Central core method with complete removal of old embankments

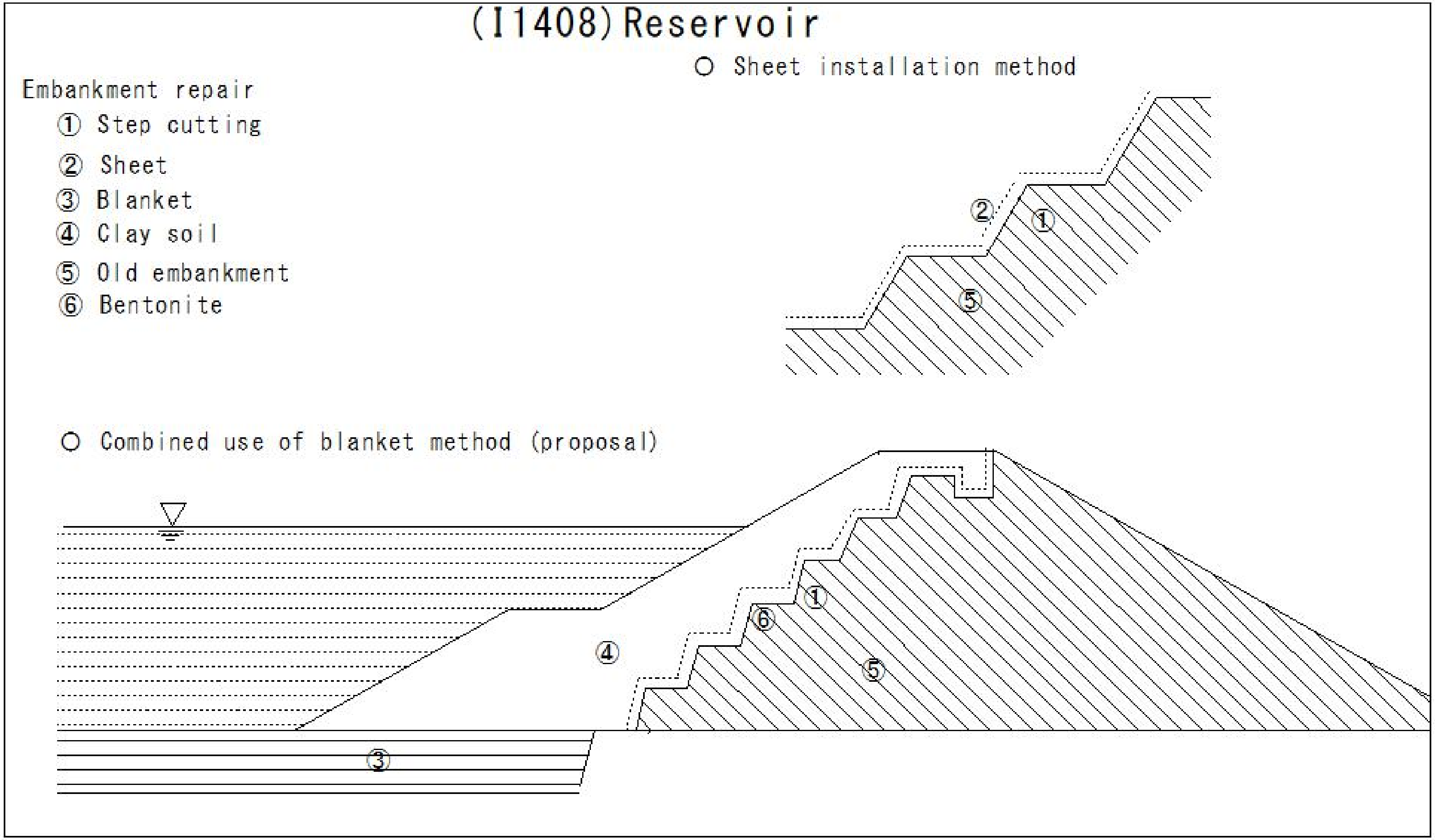
For small irrigation ponds

Complete removal of old embankments



Fill type dam

(I1408)Reservoir



(I1409)Reservoir

(I1409)Reservoir

Embankment repair

○ Sheet installation method

Embankment base Gravel layer Rock layer

① Embankment

② Embankment embankment subsidence

③ Gap under tension block)

④ Leaking from joints and cracks in tension concrete

⑤ Block pitching

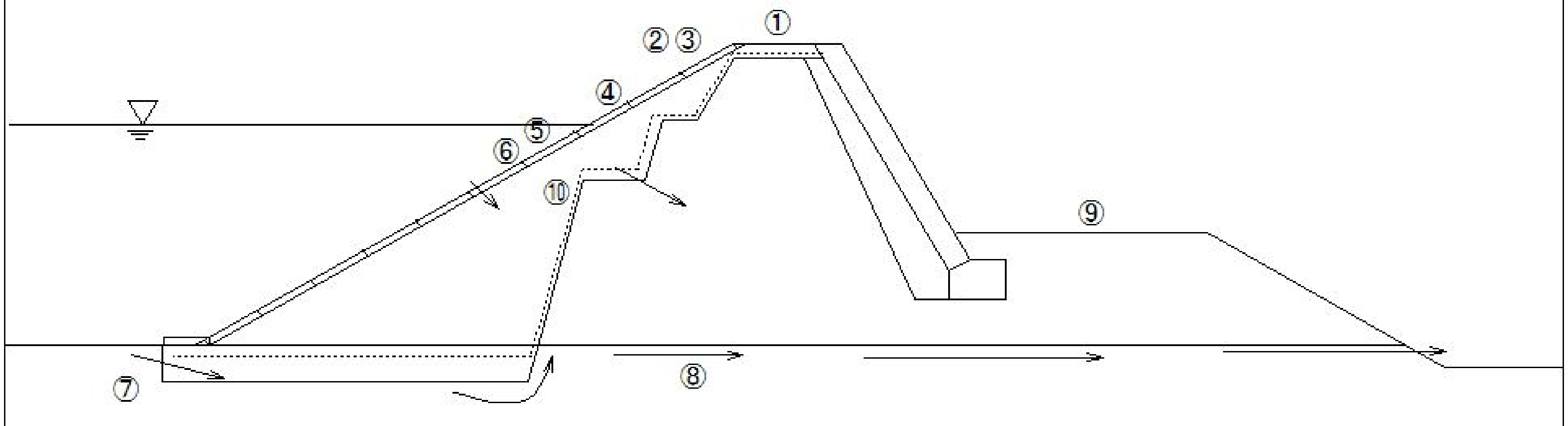
⑥ Seam of sheet

⑦ Leaking from near the bottom of the pond

⑧ Leaking route

⑨ Management road

⑩ Sheet



(I1410)Reservoir

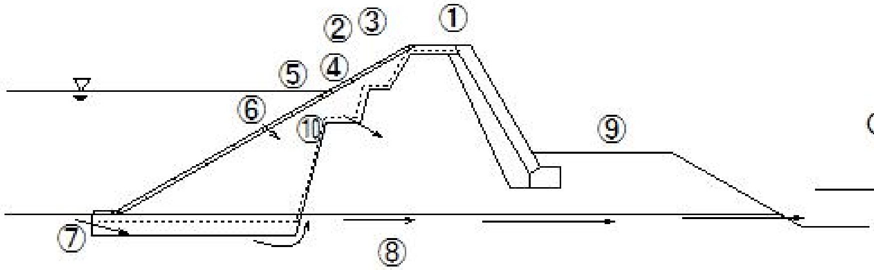
(I1410)Reservoir

Embankment repair

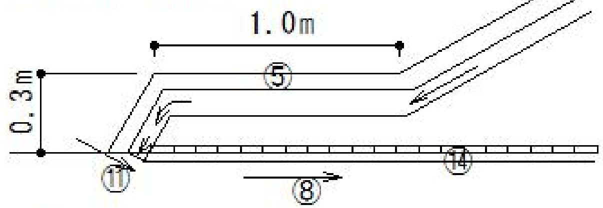
○ Sheet installation method

Embankment base Gravel layer Rock layer

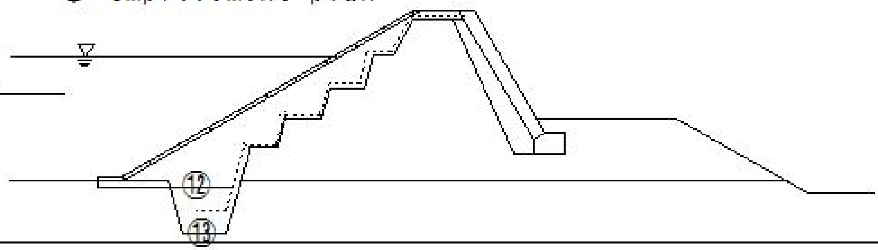
① Embankment
② Embankment embankment subsidence
③ Gap (under pitching block)
④ Leaking from joints and cracks in tension concrete
⑤ Block pitching
⑥ Seam of sheet
⑦ Leaking from near the bottom of the pond
⑧ Leaking route
⑨ Management road
⑩ Sheet
⑪ Soft rock foundation
⑫ Installation of trench
⑬ Installation of sheet in trench
⑭ Bentonite sheet



○ Foundation details



○ Improvement plan



(I1411)Reservoir

(I1411)Reservoir

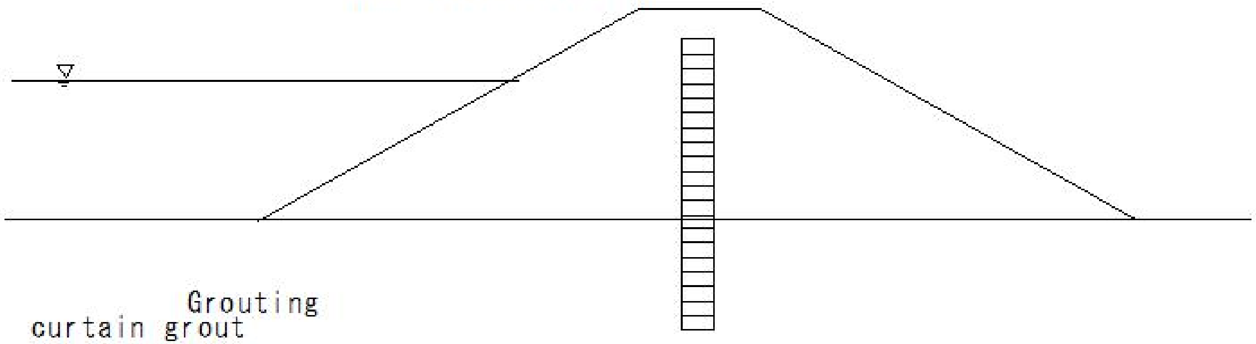
Embankment repair

○Grouting method

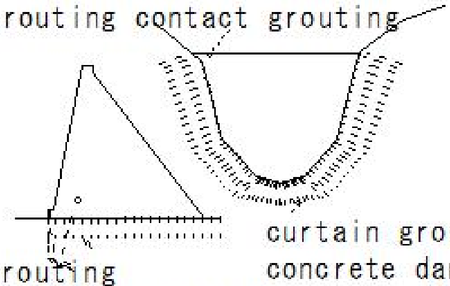
A method of injecting cement milk to create a water-stopping wall using a continuous wall

・Piping measures
・Reliable water stop

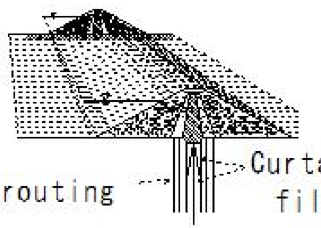
Reliable water stop



Grouting



D130



D167

D138

(I1412)Reservoir

(I1412)Reservoir

Embankment repair

○Aging of embankment

○Embankment immediately after construction

a Reservoir embankment - compacting clayey soil

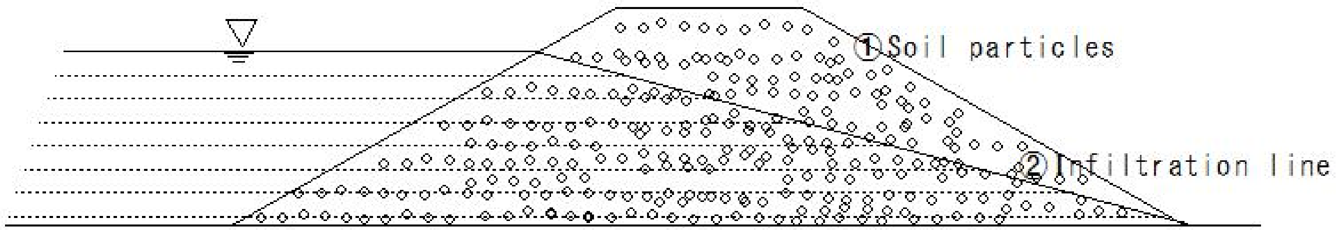
b Water passes between soil particles in embankment

c Clay in embankment - flowing down

d Gaps between soil particles

e Water-stopping effect - reduced

f Embankment deterioration → piping (water supply) → collapse



(I1413)Reservoir

(I1413)Reservoir

Embankment repair

○ Aging embankment

More than 50 years have passed since construction

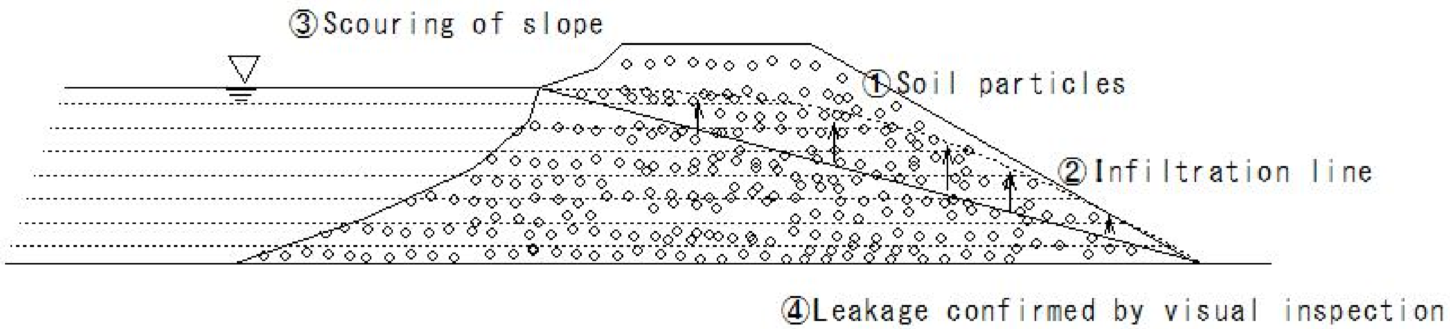
○ Changes

a Clay outflow

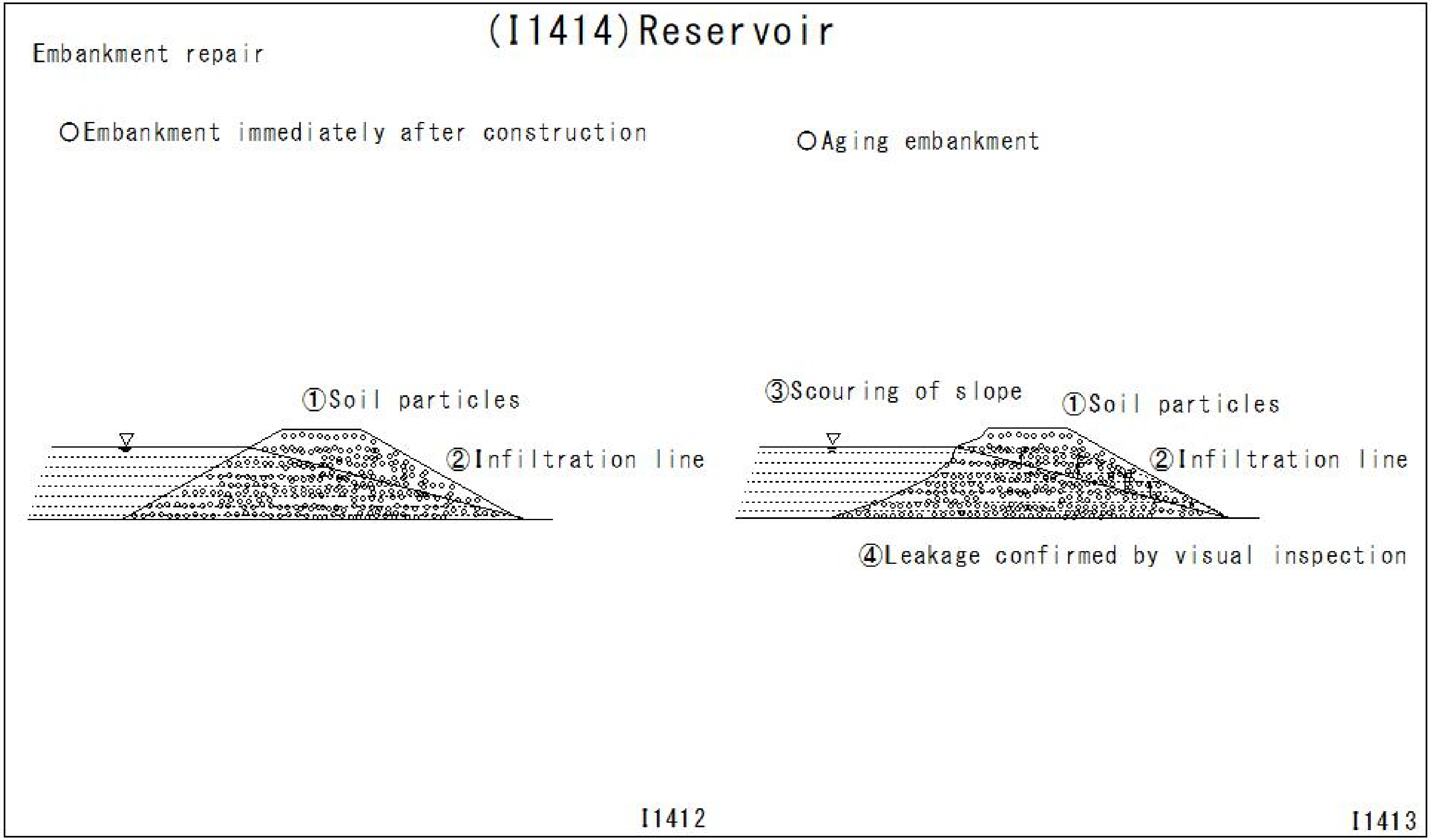
b Infiltration line rises

c Increased amount of leakage

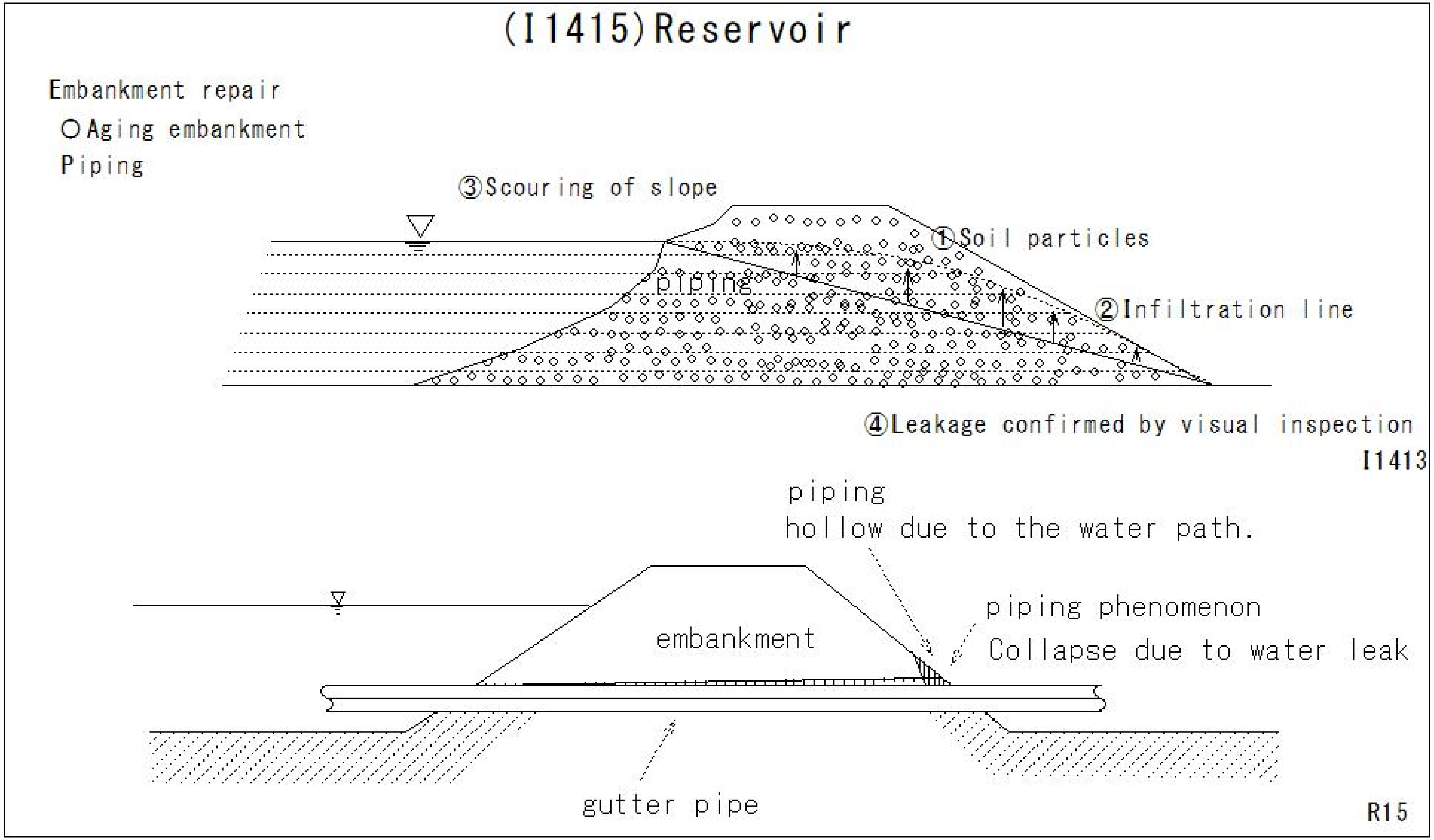
d Erosion of slope upstream of embankment



(I1414)Reservoir



(I1415)Reservoir



(I1416)Reservoir

(I1416)Reservoir

Embankment repair

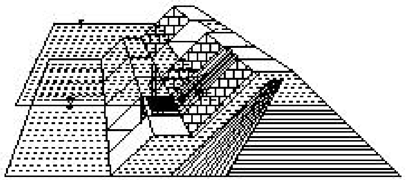
○ Reservoir collapse

Cause of collapse

a Low drainage pipe - Insufficient compaction of replacement soil

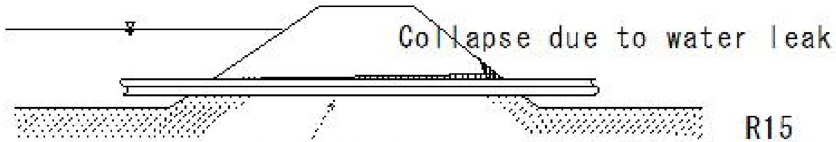
b Spring water on excavation surface - Incomplete treatment

c Subsidence - Increased leakage - Soil runoff - Hollowing of ground



I1382

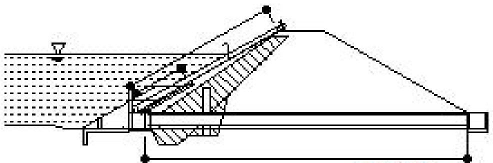
piping



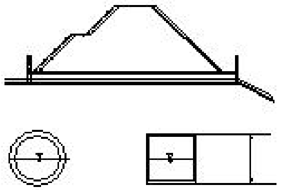
R15

I1415

⑤ Rolling compaction of Bottom gutter area



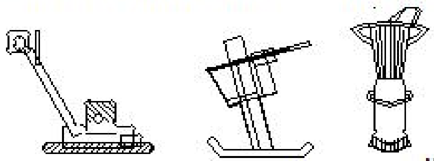
I1392



I705

E604

I1395



Tampa Rammer

M191

E359 I1406

(I1417)Reservoir

(I1417)Reservoir

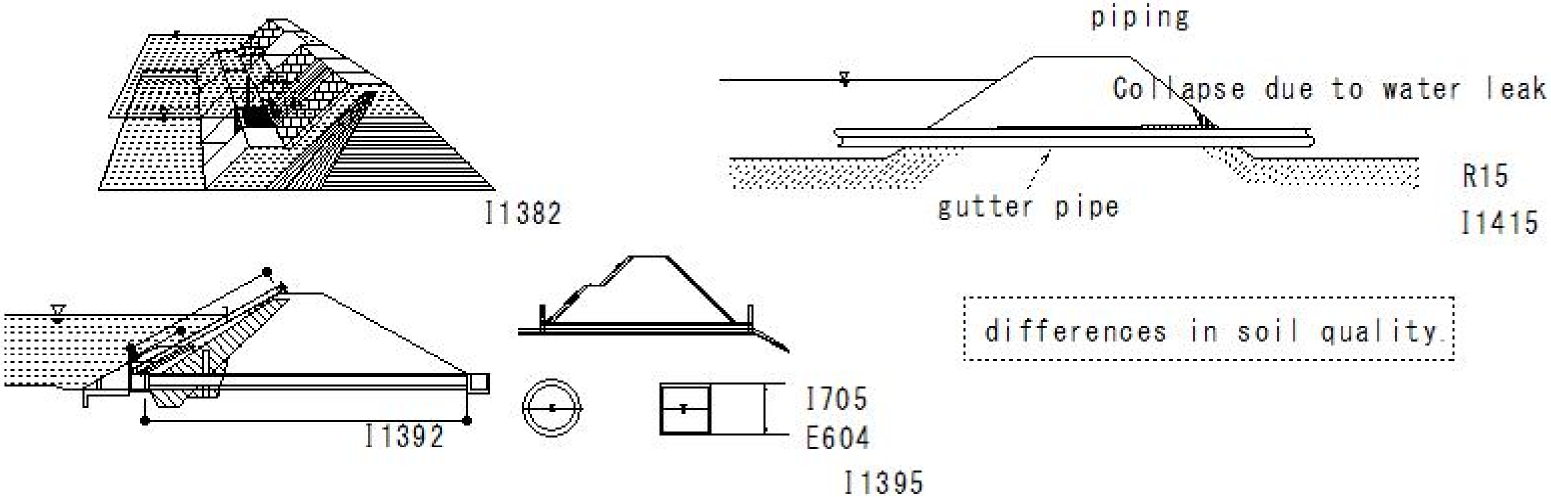
Embankment repair

○ Reservoir collapse

Cause of collapse

Partial repair of embankment due to repair of inclined and bottom gutters

○Piping occurred at the boundary between the old embankment and the repaired part due to differences in soil quality.



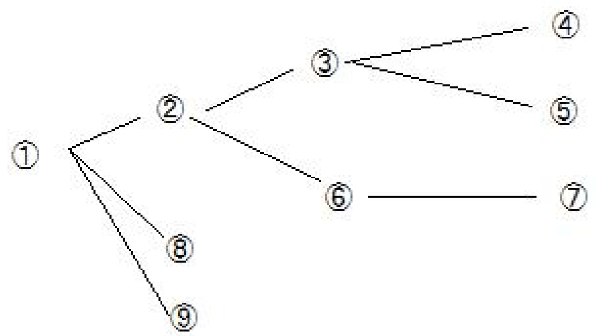
differences in soil quality.

(I1418)Reservoir

(I1418)Reservoir

Basic knowledge of soil

① Reservoir construction
② Earthworks
③ Stability of embankment
④ Decrease in consolidation
⑤ Increase in shear strength and deformation resistance
⑥ Prevention of water leakage
⑦ Decrease in permeability
⑧ Concrete construction
⑨ Other constructions



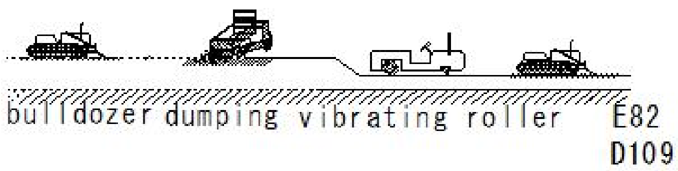
(I1419)Reservoir

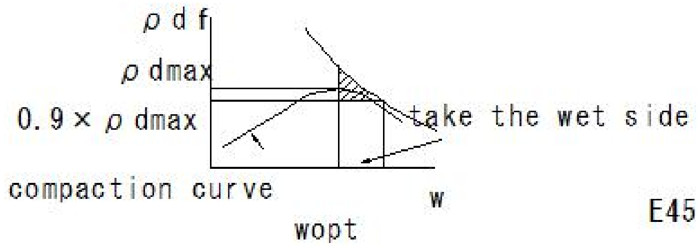
(I1419)Reservoir

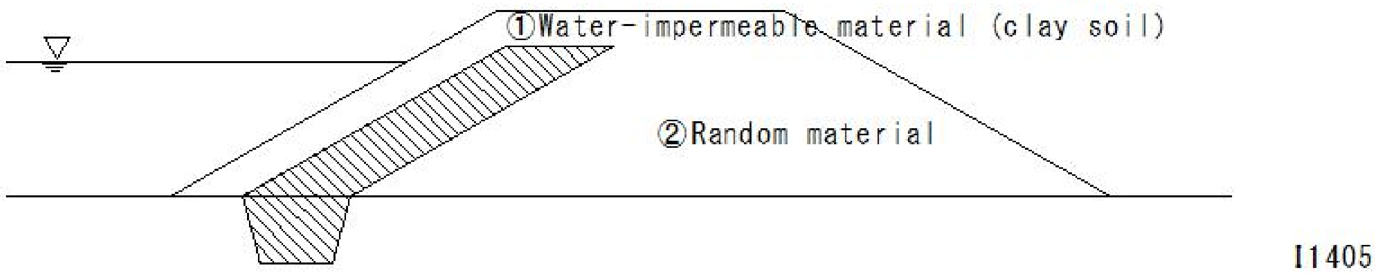
Basic knowledge of soil

Soil compaction

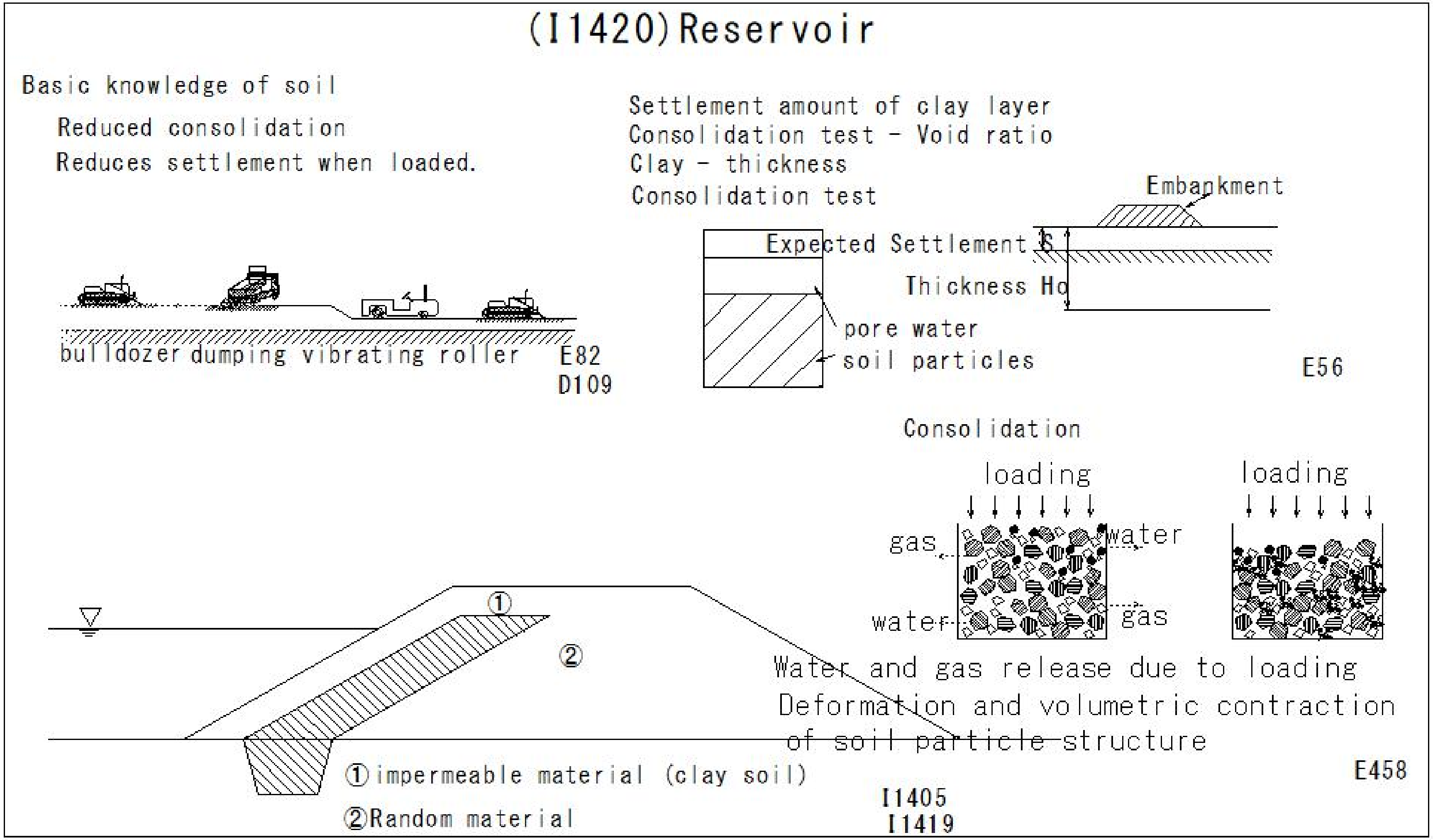
The application of force to soil to expel air from the soil pores and increase its density.







(I1420)Reservoir



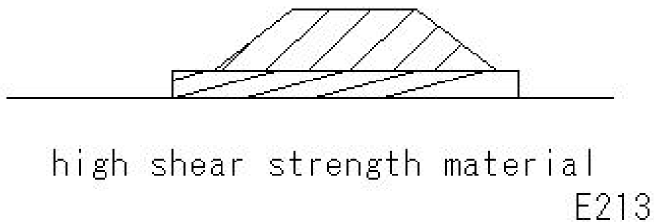
(I1421)Reservoir

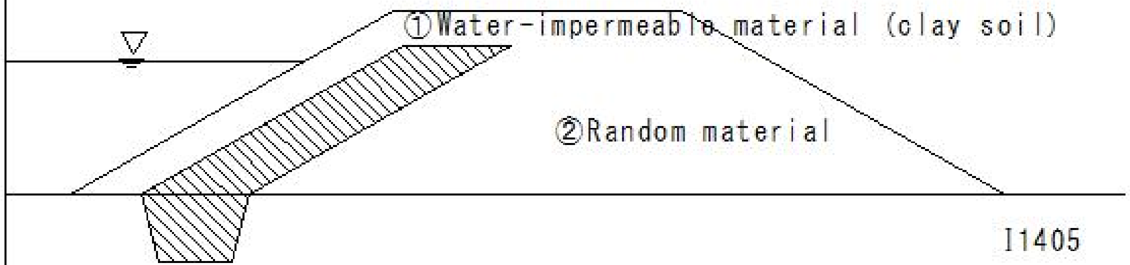
(I1421)Reservoir

Basic knowledge of soil

Increased shear strength and deformation resistance

Improved interlocking of soil particles increases shear resistance, providing the necessary strength to soil structures.





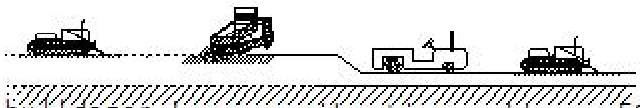
(I1422)Reservoir

(I1422)Reservoir

Basic knowledge of soil

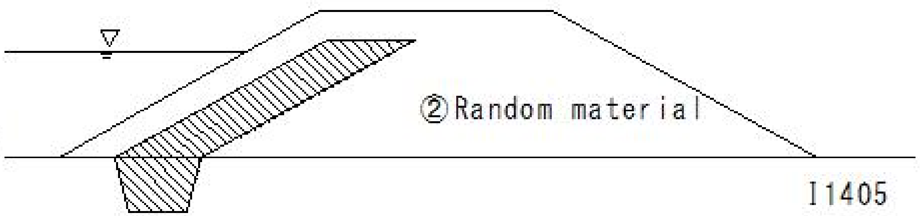
Reduced permeability

By making it harder for water to pass through, it prevents soil softening and expansion caused by rainwater infiltration, and keeps embankment leakage within the standard value.



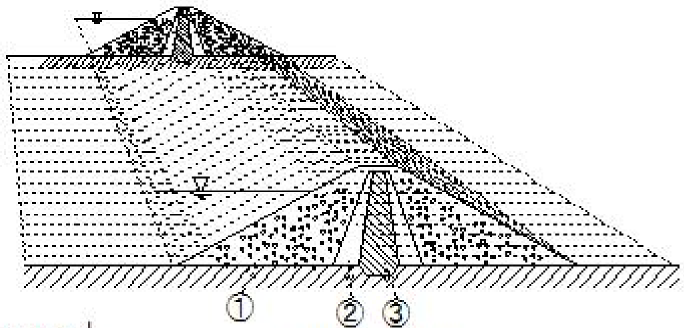
bulldozer dumping vibrating roller

E82
D109



I1405

①permeable material
②Semi-permeable material
③Waterproof(Impermeable) material



zone type

spillway installed on the ground

D6
R590

(I1423)Reservoir

(I1423)Reservoir

Basic knowledge of soil

Classification by particle size

Classification of soil particles by particle size and their names

Soil - particle size 75mm or lessil - particle size 75mm or less

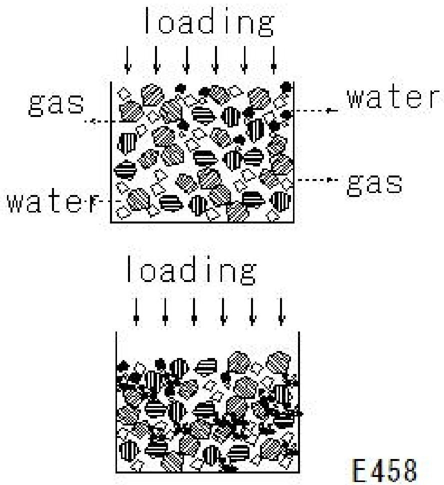
Soil with a lot of silt or clay particles is fine-grained soil

It is sticky, so it is called clayey soil

Soil with a lot of sand or gravel particles is called coarse-grained soil

In case of there is a lot of sand, it is called sandy soil,

In case of there is a lot of gravel, it is called gravelly soil



E458

○Classification of soil particles by particle size and their names

①Fine		④Coarse						⑬Stone	
②Clay	③Silt	⑤Sand			⑨Gravel			⑭Stone	
		⑥Fine sand	⑦Medium sand	⑧Coarse sand	⑩Fine gravel	⑪Medium gravel	⑫Coarse gravel	⑮Coarse stone	⑯Boulder

0.005 0.075 0.25 0.85 2.0 4.75 19 75 300 (mm)

Particle size

(I1424)Reservoir

(I1424)Reservoir

Basic knowledge of soil

Soil particles

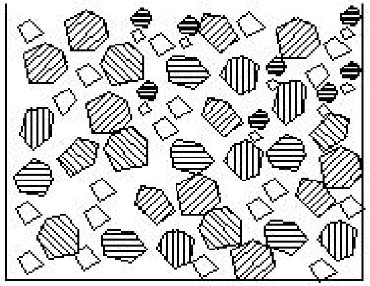
Fine gravel (2-4.75mm)

Coarse sand (0.85-2mm)

Medium sand (0.25-0.85mm)

Clay (0.005mm or less)

Silt (0.005-0.075mm)



E458

○Classification of soil particles by particle size and their names

①Fine		④Coarse						⑬Stone	
②Clay	③Silt	⑤Sand			⑨Gravel			⑭Stone	
		⑥Fine sand	⑦Medium sand	⑧Coarse sand	⑩Fine gravel	⑪Medium gravel	⑫Coarse gravel	⑮Coarse stone	⑯Boulder

Particle size: 0.005 — 0.075 — 0.25 — 0.85 — 2.0 — 4.75 — 19 — 75 — 300 (mm)

(I1425)Reservoir

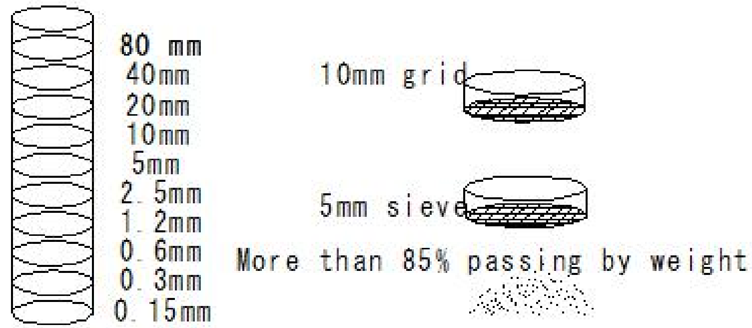
(I1425)Reservoir

Basic knowledge of soil

Grain size test

Coarse particles - sieving test

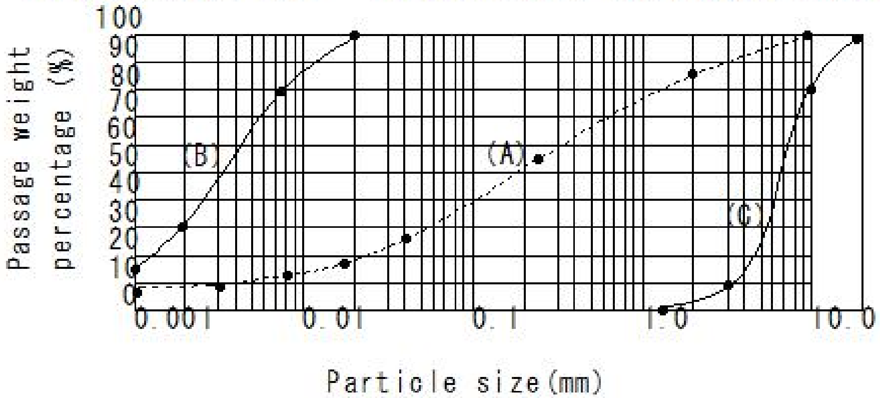
Fine particles - settling test



Grain size test

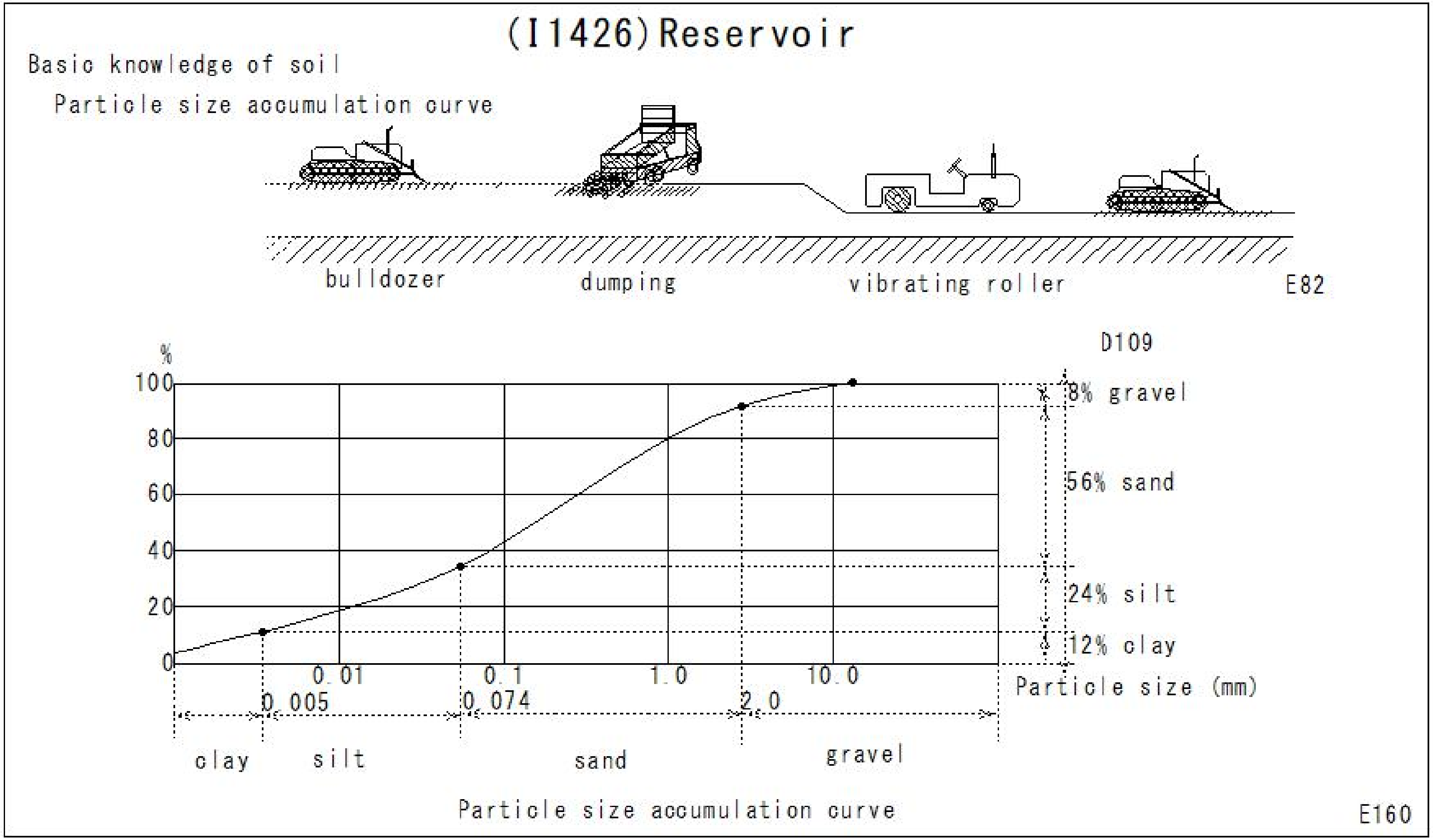
CM790

Particle size test - Particle size accumulation curve



E158

(I1426)Reservoir

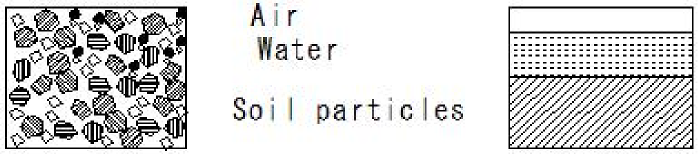


(I1427)Reservoir

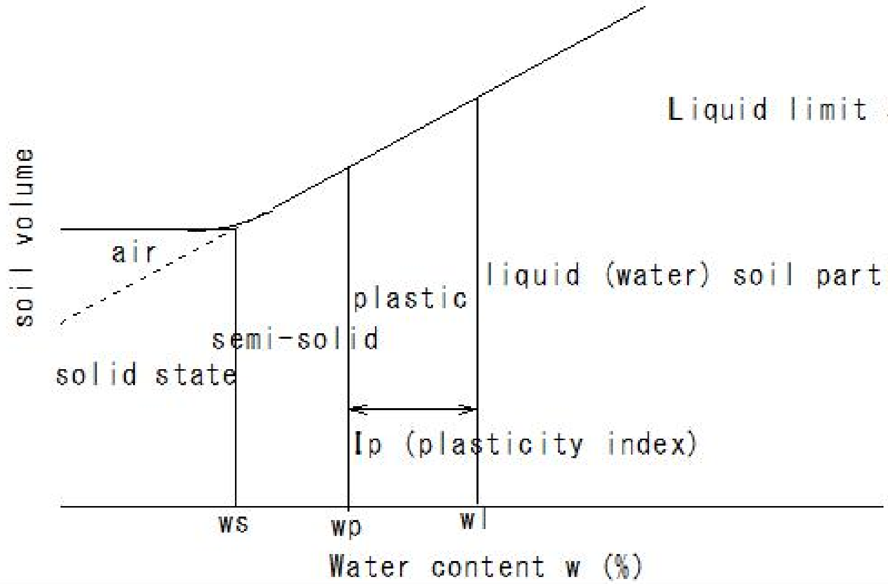
(I1427)Reservoir

Basic knowledge of soil

Liquid and plastic limits of soil



Liquid limit and plastic limit



wL: liquid limit

wp: plastic limit

ws: shrinkage limit

Consistency limits for each limit

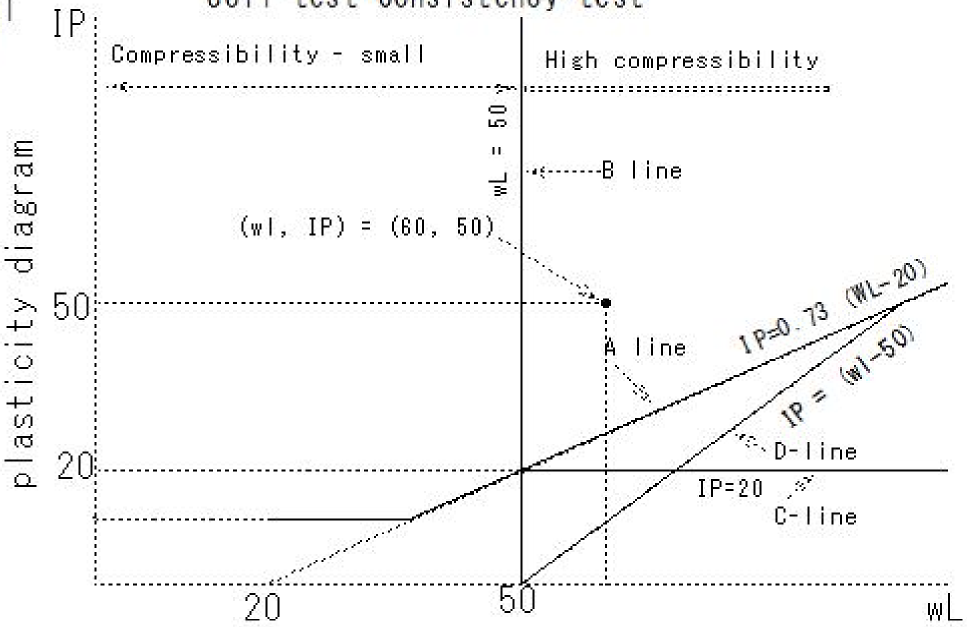
E214

(I1428)Reservoir

(I1428)Reservoir

Soil test-Consistency test

Basic knowledge of soil
Plasticity diagram



wl: liquid limit: minimum water content ratio indicating liquidity

wp: plastic limit: maximum water content in semi-solid state

Plasticity index: Ip = wl - wp

Plasticity diagram: Used to determine soil properties
defined by coordinates (wl, IP)

E36

(I1429)Reservoir

(I1429)Reservoir

Basic knowledge of soil
Soil classification: Geotechnical materials

Suitability of embankment materials

Suitability of embankment materials

Embankments such as roads*	Soil classification	Embankment embankment
1	Gravel (G)	7
2	Gravel soil (GF)	1
3	Sand (S)	6
4	sandy soil (SF)	2
5	Silt (M)	3
6	Cohesive soil (C)	4
8	Organic soil (O)	8
7	Volcanic ash chamber cohesive soil (V) **	5

*: Embankment bearing capacity is a major factor

Proportional in order of particle size

**: (V) is not stable as a slope surface

E61

(I1430)Reservoir

(I1430)Reservoir

Basic knowledge of soil
Soil classification: Geotechnical materials

Soil classification-Name of soil particles based on particle size

Name of soil particles based on particle size

0	0.001	0.005	0.074	2.0 Particle size (mm)
colloid	clay	silt	fine sand sand coarse sand	gravel
small ←		Water permeability	→	large

E157

(I1431)Reservoir

(I1431)Reservoir

Basic knowledge of soil

Soil classification: Geotechnical materials

soil material	coarse soil	Grained soil (G)	Gravel (G)
			Gravel soil (GF)
		Sand grain soil (S)	Sand (S)
			Sandy soil (SF)
	Fine soil (F)		Silt (M)
			Clay (C)
			Organic soil (O)
			Volcanic cohesive soil(V)
	High organic soil (Pt)		Peat (Pt)
			Black mud (Mk)
			Waste (W)

(I1432)Reservoir

(I1432)Reservoir

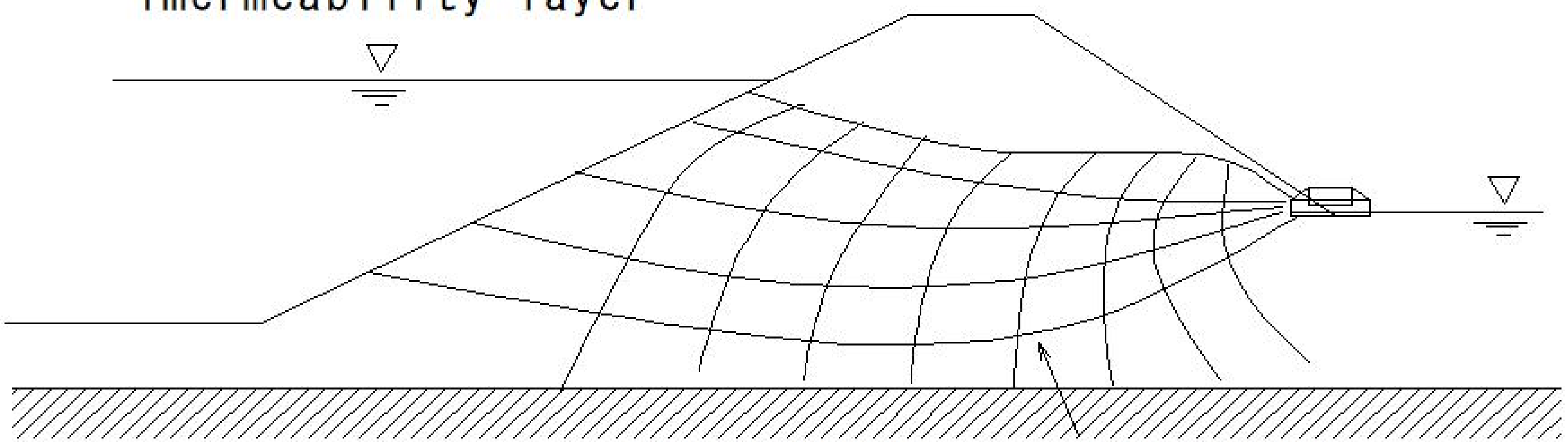
Basic knowledge of soil
Soil permeability

Name of soil particles based on particle size

0	0.001	0.005	0.074	2.0 Particle size(mm)
colloid	clay	silt	fine sand sand coarse sand	gravel
small		Water permeability	→	large

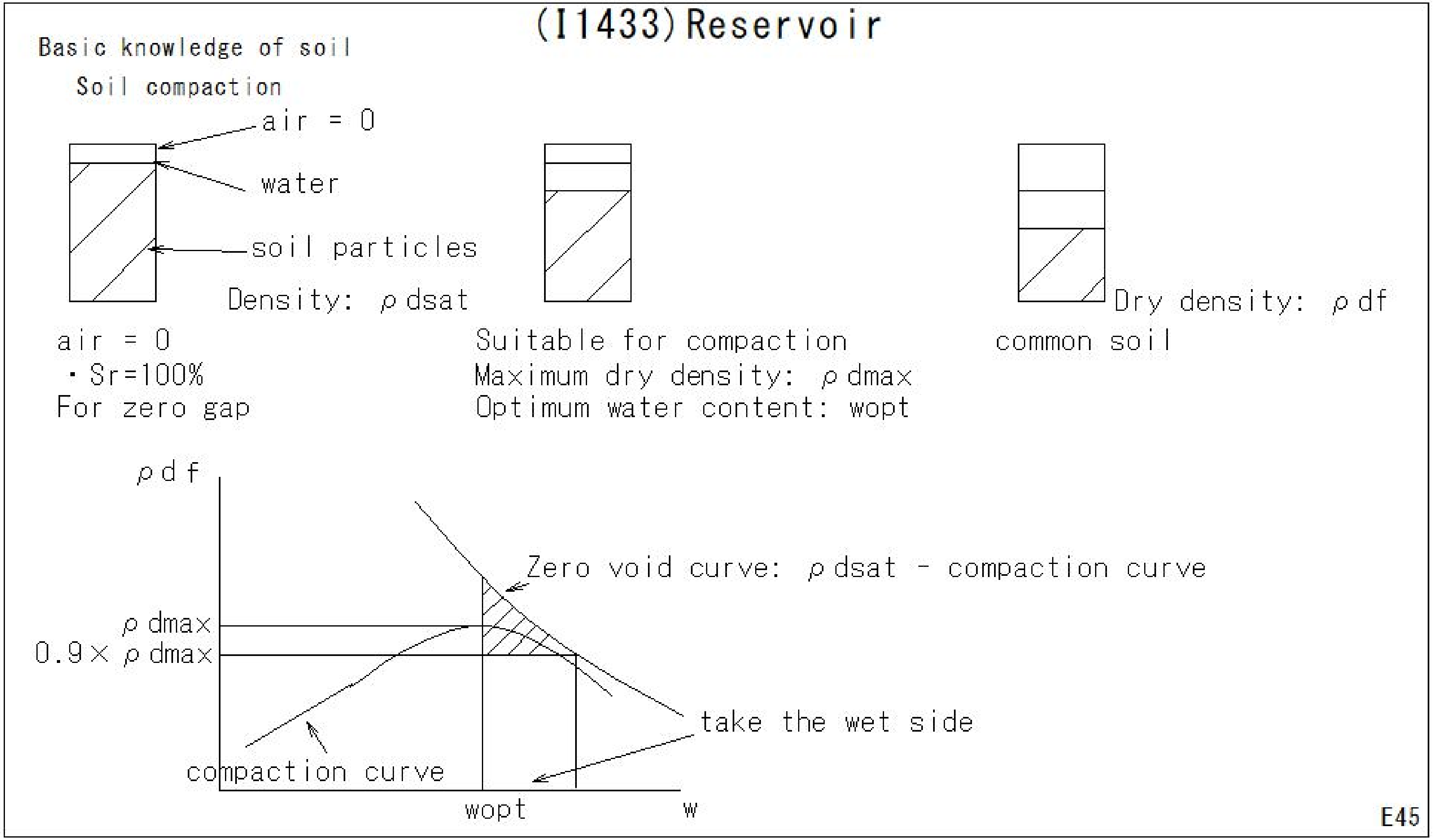
imermeability layer

E157



E609

(I1433)Reservoir



(I1434)Reservoir

(I1434)Reservoir

Basic knowledge of soil

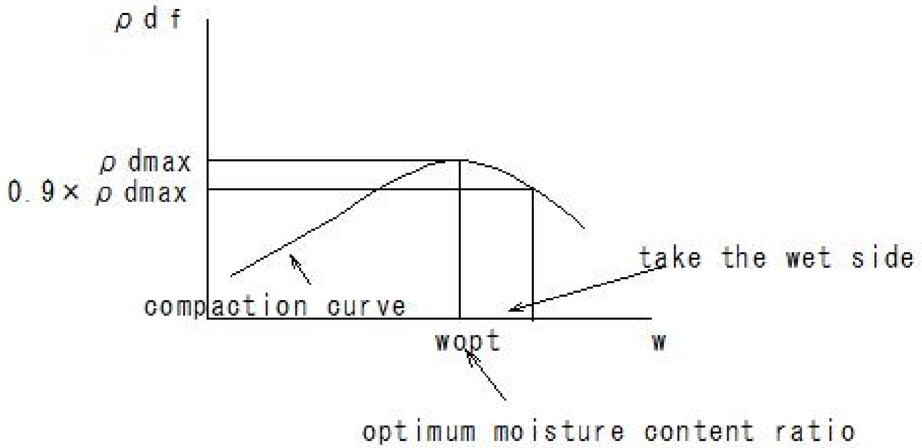
Soil compaction

Notes on compaction

②Moisture content ratio of embankment material:

Around the optimum moisture content ratio

Wet side - trench excavation - lowering of water content - compaction



・Compaction degree Cd=((ρdf/ρdmax)*100(%)

(I1435)Reservoir

(I1435)Reservoir

Basic knowledge of soil

Suitability by soil type

Suitability of embankment materials

Embankments such as roads*	Soil classification	Embankment embankment
1	Gravel (G)	7
2	Gravel soil (GF)	1
3	Sand (S)	6
4	sandy soil (SF)	2
5	Silt (M)	3
6	Cohesive soil (C)	4
8	Organic soil (O)	8
7	Volcanic ash chamber cohesive soil (V) **	5

*: Embankment bearing capacity is a major factor

Proportional in order of particle size

**: (V) is not stable as a slope surface

E61

(I1436)Reservoir

(I1436)Reservoir

Basic knowledge of soil

Considerations for construction

Considerations for construction (embankment test: compaction status & each test)

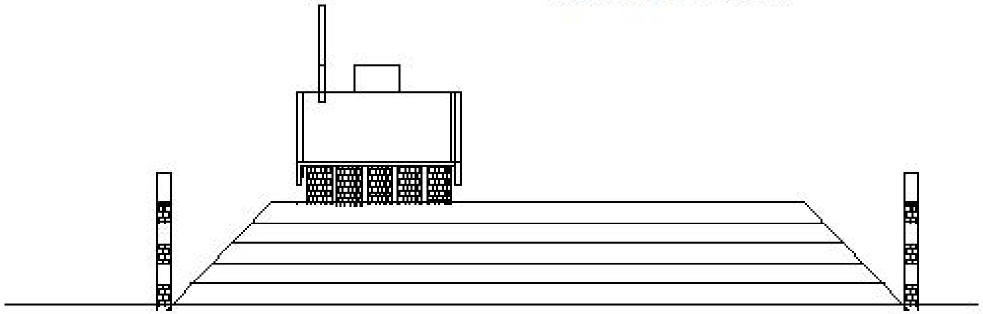
①For embankment tests, select the compaction model, spreading thickness, and number of compaction times

②After compaction, conduct on-site density test and on-site permeability test

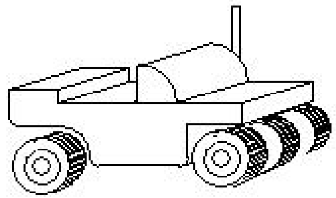
③For embankment tests, select the compaction model, spreading thickness, and number of compaction times that can ensure the construction management density determined by the indoor compaction test

④For clayey soil, the weight of the compactor must be at least 3t

Embankment test



Tire roller



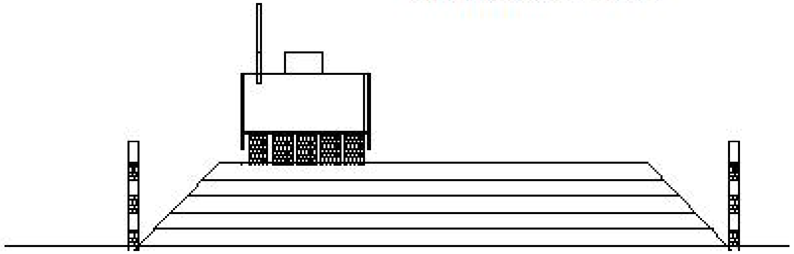
E315

M385

(I1437)Reservoir

(I1437)Reservoir

Embankment test



I1436

Basic knowledge of soil

Considerations for construction

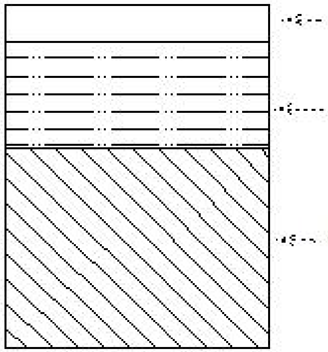
Daily construction management

①Construction moisture content

Perform daily

There are frying pan method, RI method, etc.

(E31)Soil test-Water content test



soil model

(1) Water content test

(2) Dry the sample and measure the moisture content

(3) Water content ratio w (%) =

mass of soil x 100/mass of soil particles

・How to use the results

・Soil compaction

E31

(I1438)Reservoir

(I1438)Reservoir

Basic knowledge of soil

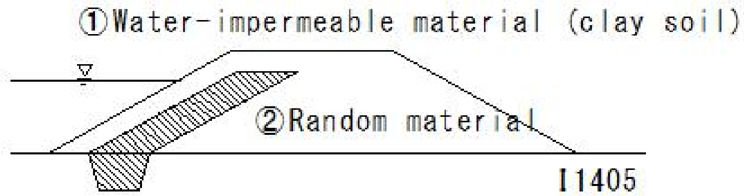
Considerations for construction

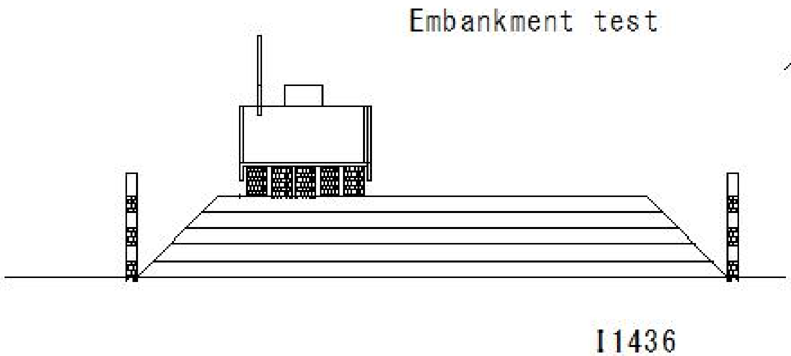
Daily construction management

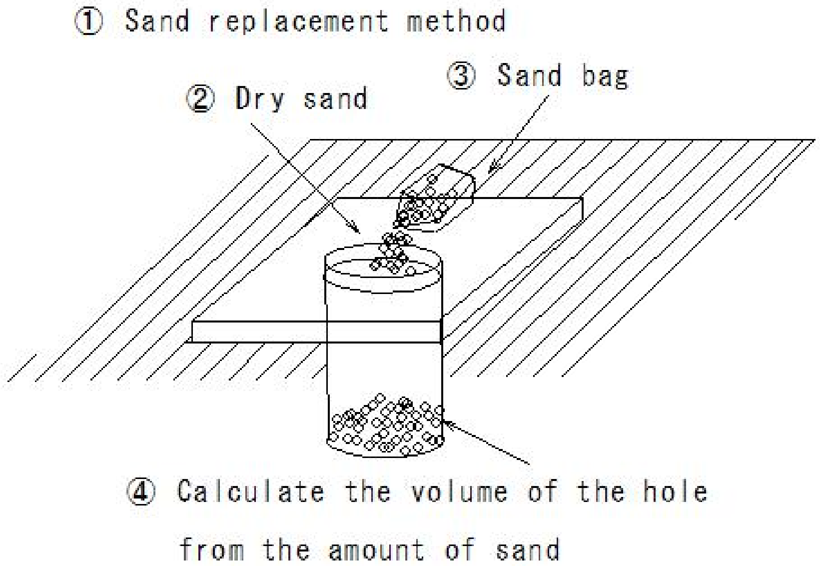
②Site density

Perform at approximately one location per 50m length and 0.6m embankment height

Sand replacement method







E18

(I1439)Reservoir

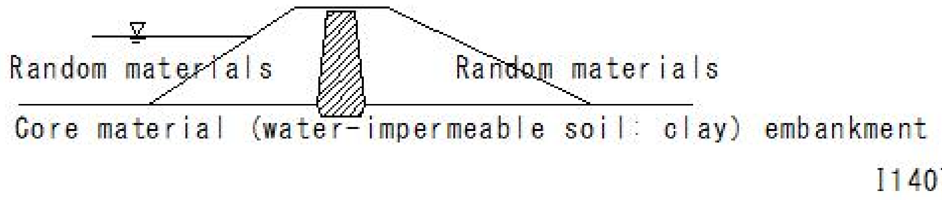
(I1439)Reservoir

Basic knowledge of soil

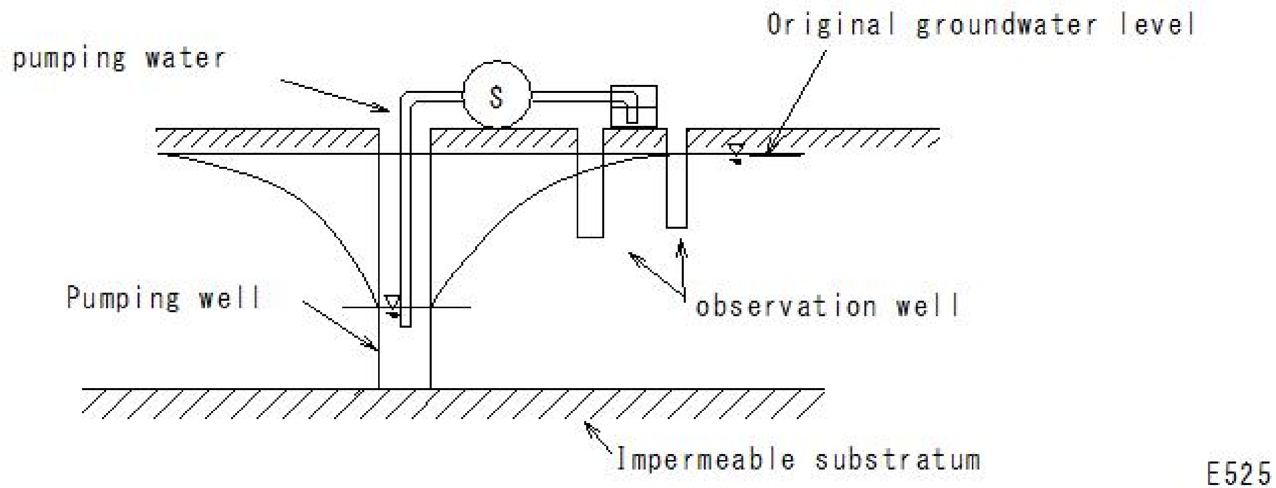
Considerations for construction

Daily construction management

③Site permeability



field permeability test



(I1440)Reservoir

(I1440)Reservoir

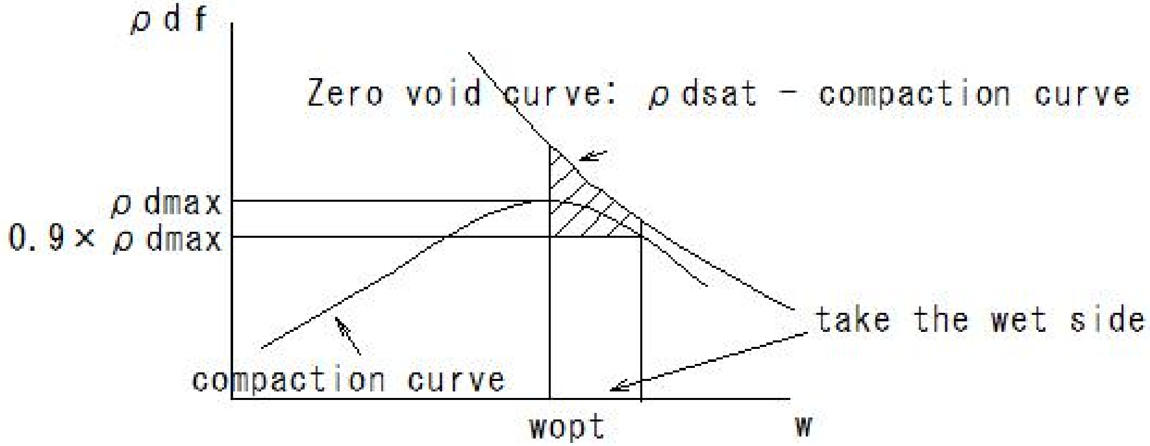
Basic knowledge of soil

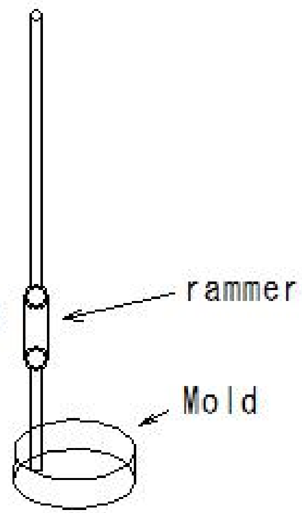
Construction points to note

Control of construction moisture content: Frying pan method

① To check the construction moisture content

② Measure the moisture content of the blade clay and the sheath clay





- Compaction degree $Cd=((\rho df/\rho dmax)*100(\%)$

  Cd≧90　Embankment roadbed

  Cd≧95 Roadbed/Roadbed

- Tamping method

E46

(I1441)Reservoir

(I1441)Reservoir

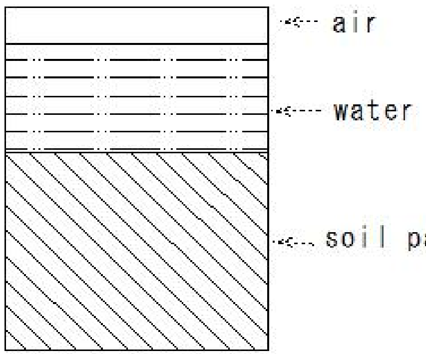
Basic knowledge of soil

Construction points to note

Controlling the moisture content of soil during construction: Microwave method

1. Use a microwave to evaporate the moisture in the soil
2. The moisture content can be calculated in about 15 minutes
3. For soil with a grain size of 10 mm or less

Water content test



soil model

(1) Water content test

(2) Dry the sample and measure the moisture content

(3) Water content ratio w (%) =

mass of soil x 100/mass of soil particles

・How to use the results

・Soil compaction

E31

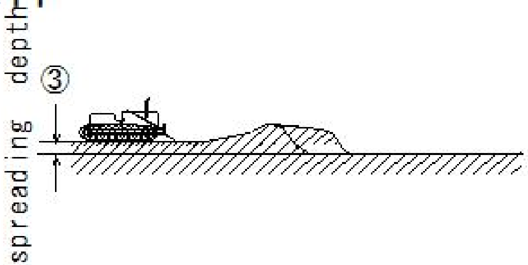
(I1442)Reservoir

(I1442)Reservoir

Basic knowledge of soil

Construction points to note

In case of compaction is good



① In case of the moisture content is appropriate

② The ruts of the compactor are not noticeable

③ Compaction of Water-impermeable material (clay soil) is done by rolling out 20-25cm

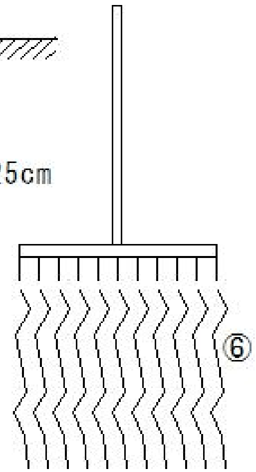
④ Work with a finishing thickness of 15-20cm

⑤ In case of rolling out

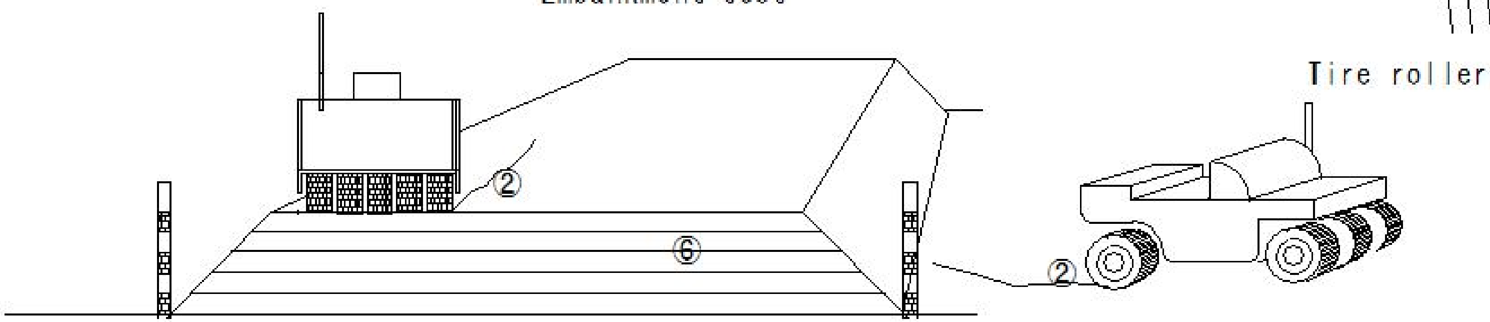
⑥ Scrap off the top of the compacted layer with a rake, etc.

a Water-impermeable material (clay soil)= 95% or more

b Random material = 95% or more



Embankment test



E315

M385

(I1443)Reservoir

(I1443)Reservoir

Basic knowledge of soil

Construction points to note

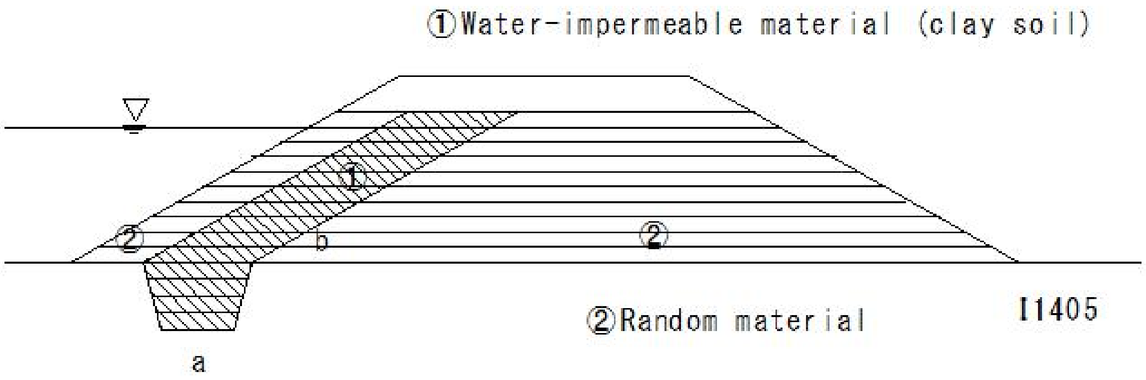
In case of compaction is good

Construction of Water-impermeable material (clay soil) - In case of compaction is good

○ Check the trench foundation

a Does it reach the foundation?

b Simultaneous construction of Water-impermeable material (clay soil) + Random material



(I1444)Reservoir

(I1444)Reservoir

Basic knowledge of soil

Construction points to note

In the case of poor compaction of impermeable material (clay soil) construction

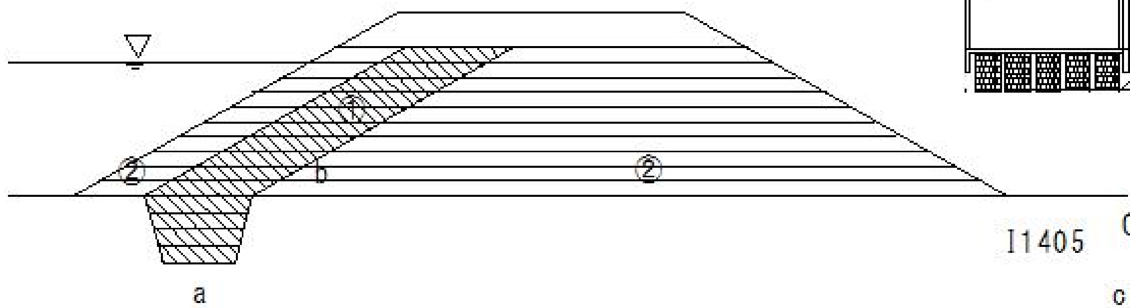
① In case of impermeable material (clay soil) construction is performed when the moisture content exceeds the construction moisture content

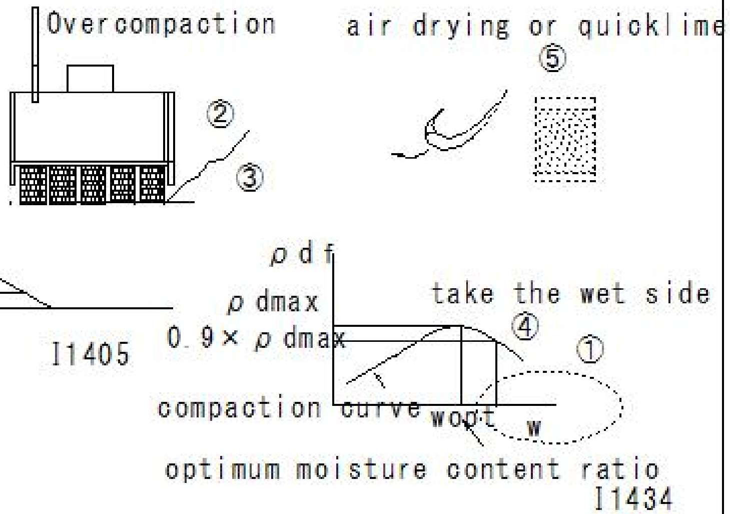
② Overcompaction occurs

③ The compactor tracks are prominent

④ The construction management density cannot be ensured

⑤ The construction moisture content must be adjusted by air drying or quicklime, etc.





①Water-impermeable material (clay soil)

②Random material

(I1445)Reservoir

(I1445)Reservoir

Basic knowledge of soil

Construction points to note

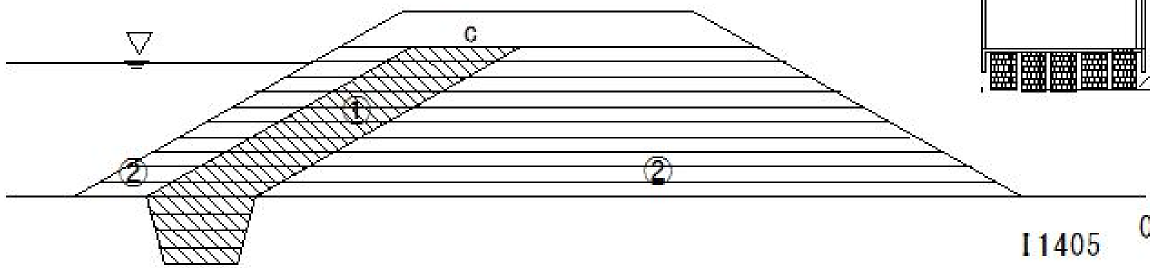
In the case of poor compaction of impermeable material (clay soil) construction

a Overcompaction due to excessive moisture content

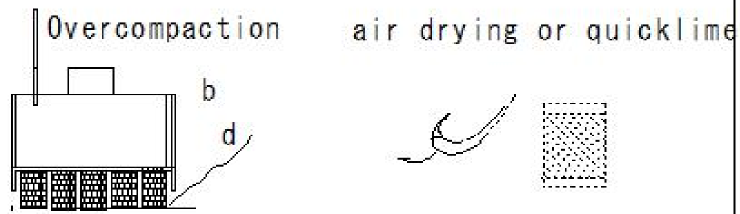
b Insufficient compaction

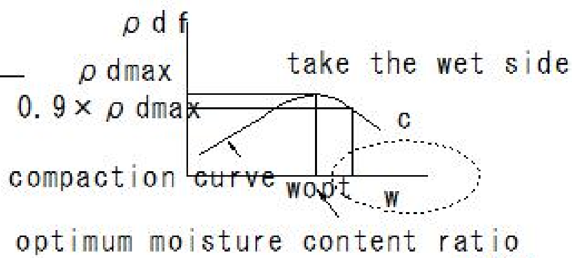
c Overcompaction due to excessive moisture content
and incorrect impermeable material (clay soil) selection

d Situation where the compacted surface is wavy



I1405





I1434

①Water-impermeable material (clay soil)

②Random material

(I1446)Reservoir

(I1446)Reservoir

Basic knowledge of soil

Construction points to note

Construction status of impermeable material (clay soil) with boulders

a In case of the moisture content of impermeable material (clay soil) is not properly controlled during construction, it will be over-compacted, and as the embankment rises, heavy machinery construction will become impossible.

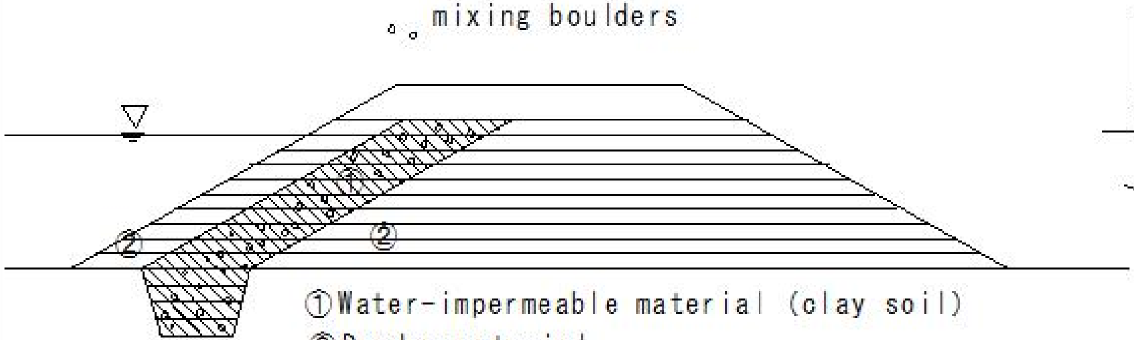
b There are cases where workability is improved by mixing boulders into impermeable material (clay soil) .

c By mixing in stones

① the construction management density of impermeable material (clay soil) cannot be ensured.

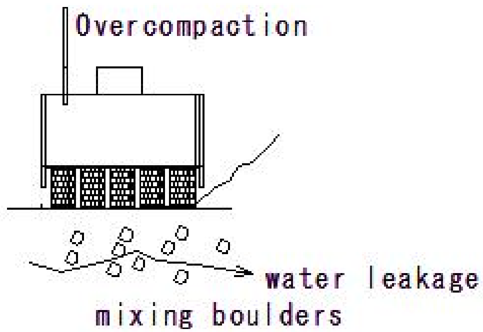
② Water paths will be formed by the boulders being laid.

③ It can cause water leakage.



①Water-impermeable material (clay soil)

②Random material



(I1447)Reservoir

(I1447)Reservoir

Basic knowledge of soil

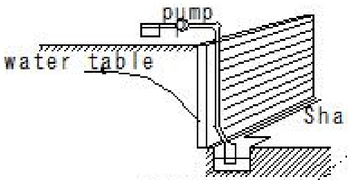
Construction points to note

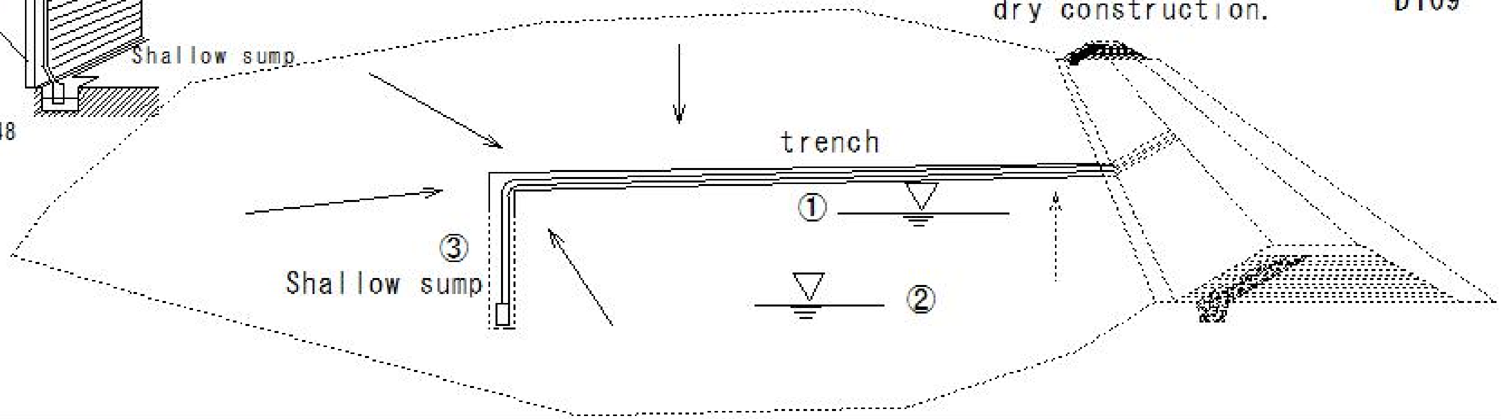
Example of Shallow sump installation

① The area where the reservoir is located is where groundwater collects, and the groundwater is at a high level.

② In case of constructing a reservoir, it is important to lower the groundwater level and perform dry construction.

③ It is necessary to install a Shallow sump on the upstream side of the trench to quickly drain the groundwater.





(I1448)Reservoir

(I1448)Reservoir

Basic knowledge of soil

Construction points to note

Treatment of the joint between the inclined gutter and the sand dump and the structure of the reservoir plug

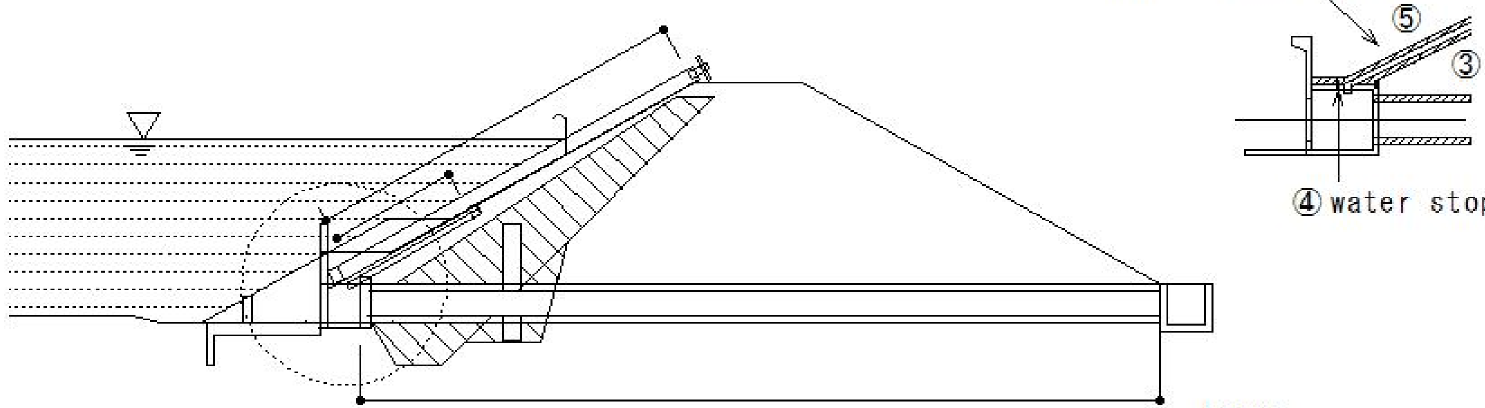
① The inclined gutter is installed on top of the clayey soil embankment

② The entire inclined gutter may settle unevenly due to the consolidation of the embankment

③ Cracks may occur at the joint between the sand dump and the inclined gutter, causing leakage.

④ A water stop plate is installed at the joint between the inclined gutter and the sand dump to reduce the risk of leakage

⑤ Additional concrete is poured to avoid corners



I1392

(I1449)Reservoir

(I1449)Reservoir

Basic knowledge of soil

Construction points to note

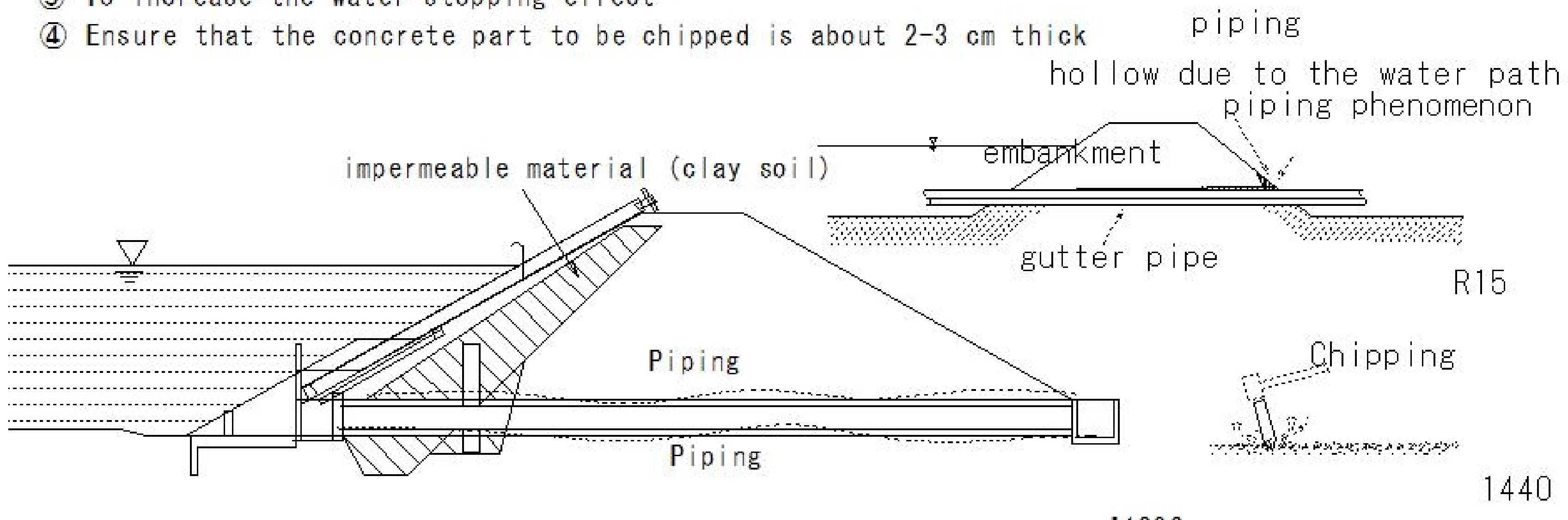
Chipping treatment of structures

① Piping is likely to occur around structures (bottom gutters, spillways, etc.) that cross the embankment.

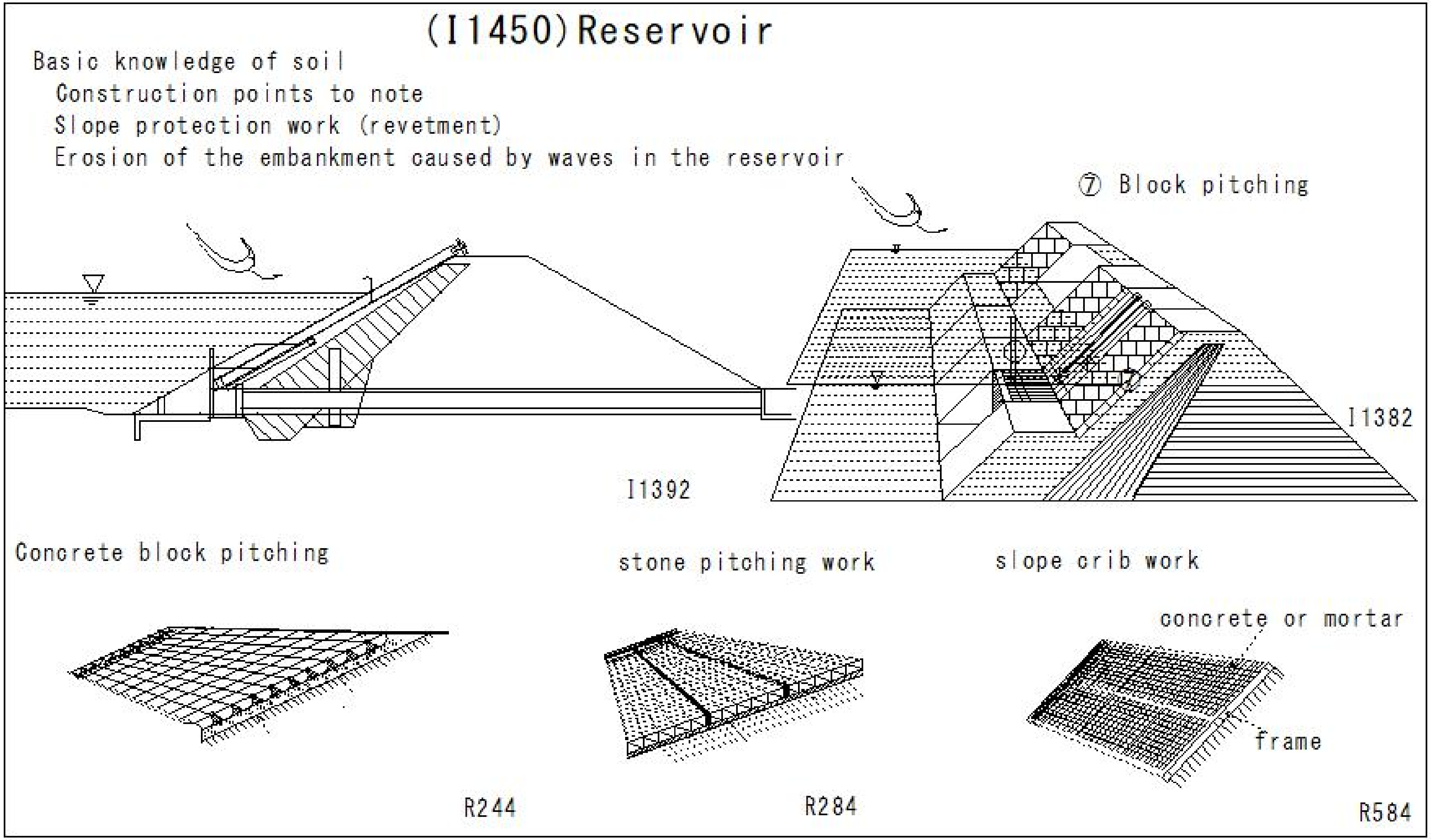
② Chipping is applied to the structure to improve the adhesion between the structure and the impermeable material (clay soil)

③ To increase the water-stopping effect

④ Ensure that the concrete part to be chipped is about 2-3 cm thick



(I1450)Reservoir



(I1451)Reservoir

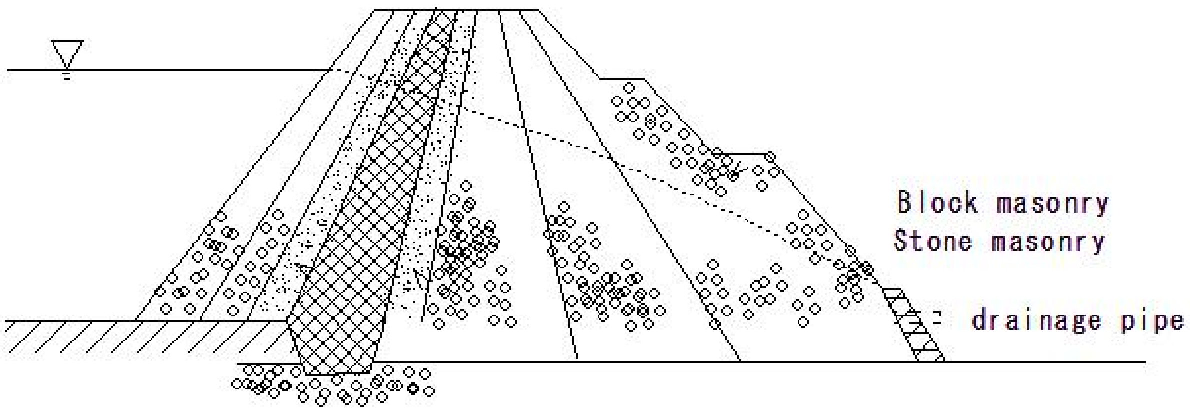
(I1451)Reservoir

Basic knowledge of soil

Construction points to note

Stone masonry drainage pipe

The purpose of stone masonry is to quickly drain the water inside the embankment



I1403
D111
R526

(I1452)Reservoir

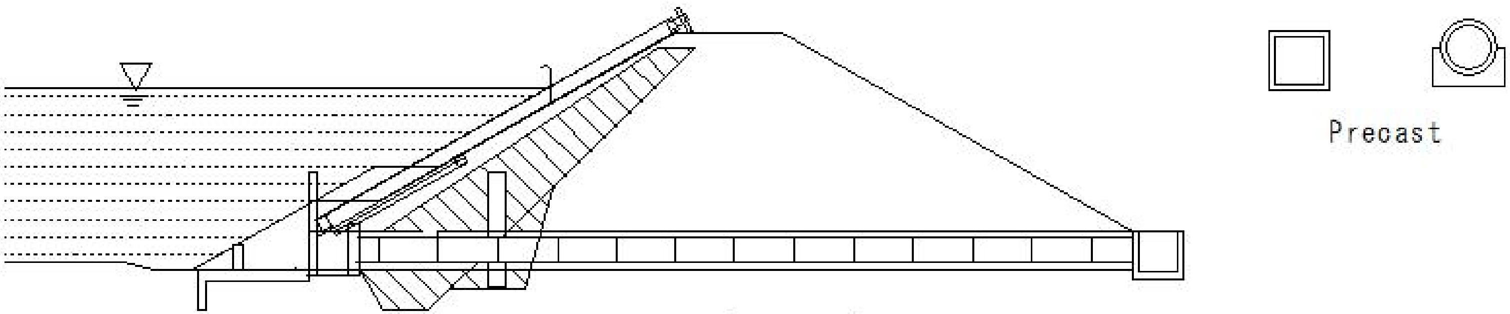
(I1452)Reservoir

Basic knowledge of soil

Construction points to note

Precast bottom gutter

The bottom gutter is the most common location for piping, so adequate water-stopping measures are required



Precast bottom gutter

I1392

(I1453)Reservoir Management Manual

(I1453)Reservoir Management Manual

Reservoir Management Manual

Reservoir Condition Check

① Have you installed sandbags or corner blocks (dropping boards, etc. into the spillway to stop water)?

② Have soil and garbage accumulated in the reservoir or spillway?

③ Are there driftwood, dead branches, bamboo, or garbage on the upstream slope of the embankment or near the inlet of the spillway?

④ Are there so many plants and bamboos that you cannot see the embankment or the management road?

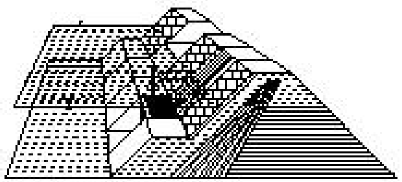
⑤ Have you ever felt that the area around the reservoir has been developed or that the water level is dangerous during heavy rains due to heavy rains?

⑥ Has any part of the embankment subsided or protruded?

⑦ Are there any leaks around the drainpipes?

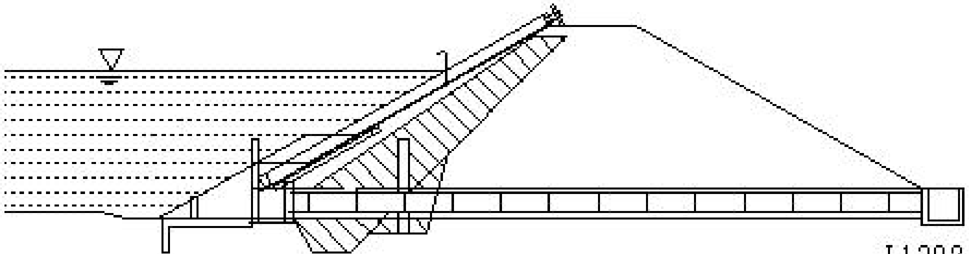
⑧ Are the winding handles and gates working properly?

⑨ Do you know what creatures live in the reservoir?



Earthen embankments

I1383



I1392

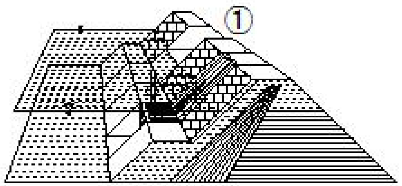
(I1454)Reservoir Management Manual

(I1454)Reservoir Management Manual

Reservoir Management Manual

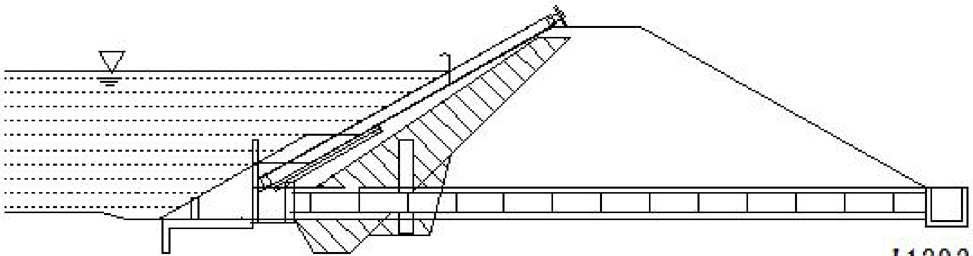
Reservoir Condition Check

① Have you installed sandbags or corner blocks
(dropping boards, etc. into the spillway to stop water)?



Earthen embankments

I1383



I1392

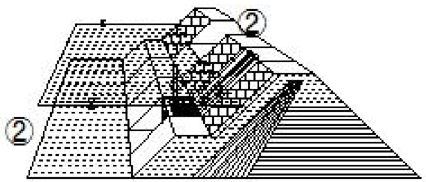
(I1455)Reservoir Management Manual

(I1455)Reservoir Management Manual

Reservoir Management Manual

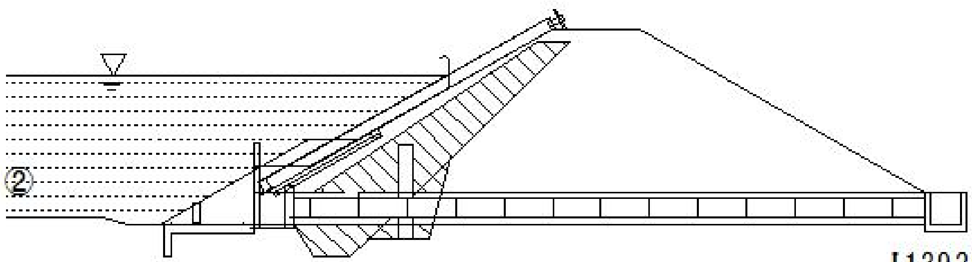
Reservoir Condition Check

② Have soil and garbage accumulated in the reservoir or spillway?



Earthen embankments

I1383



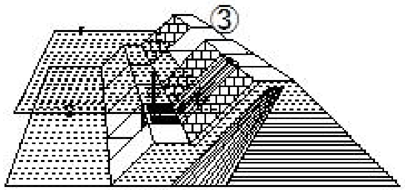
I1392

(I1456)Reservoir Management Manual

Reservoir Management Manual

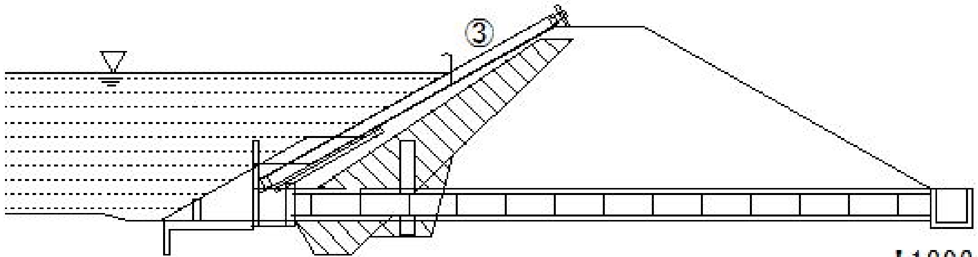
Reservoir Condition Check

③ Are there driftwood, dead branches, bamboo, or garbage on the upstream slope of the embankment or near the inlet of the spillway?



Earthen embankments

I1383



I1392

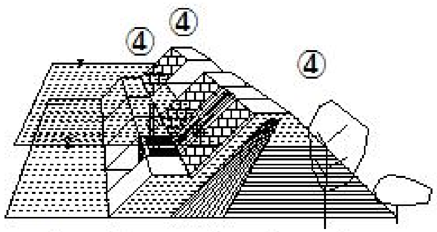
(I1457)Reservoir Management Manual

(I1457)Reservoir Management Manual

Reservoir Management Manual

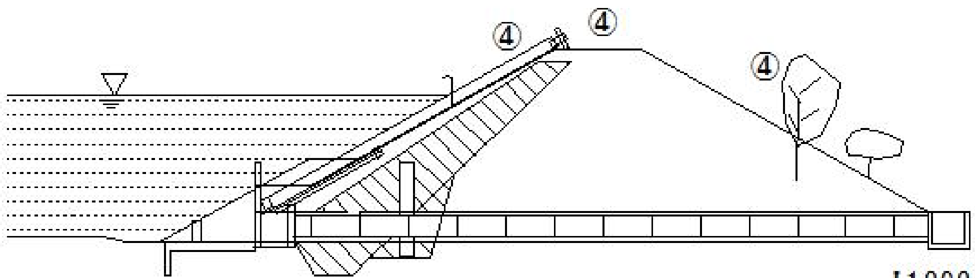
Reservoir Condition Check

④ Are there so many plants and bamboos that you cannot see the embankment or the management road?



Earthen embankments

I1383



I1392

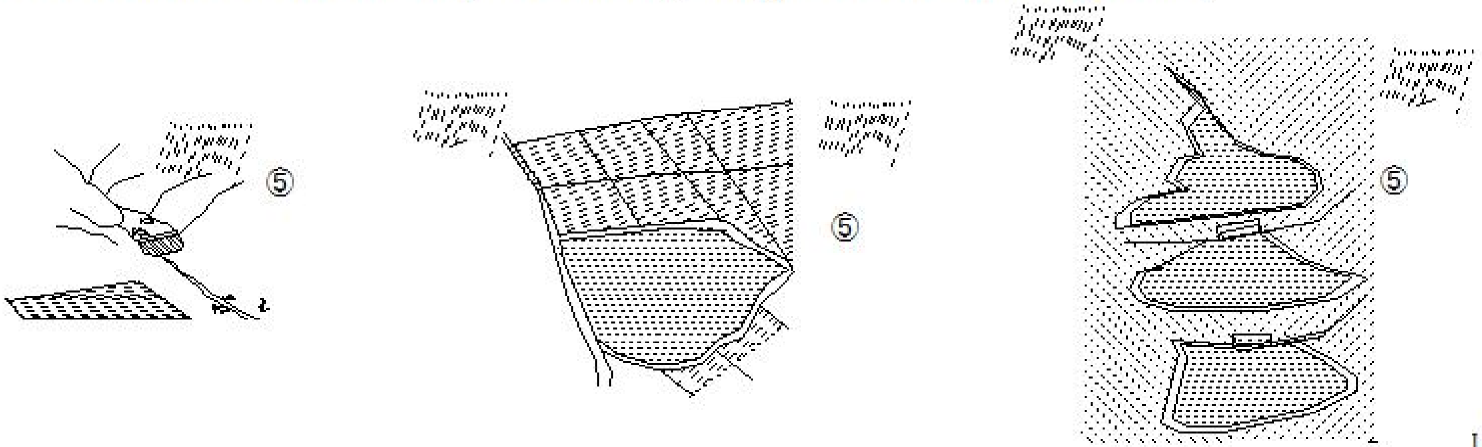
(I1458)Reservoir Management Manual

(I1458)Reservoir Management Manual

Reservoir Management Manual

Reservoir Condition Check

⑤ Have you ever felt that the area around the reservoir has been developed or that the water level is dangerous during heavy rains due to heavy rains?



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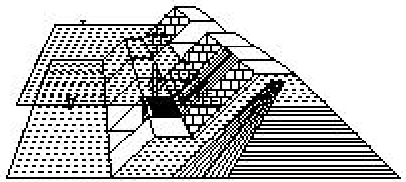
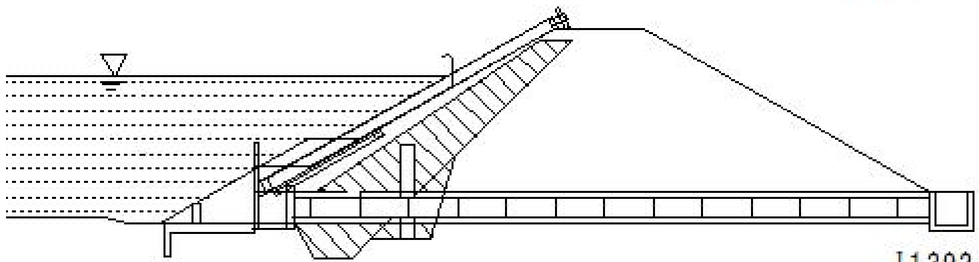


Earthen embankments

I1383



I1392

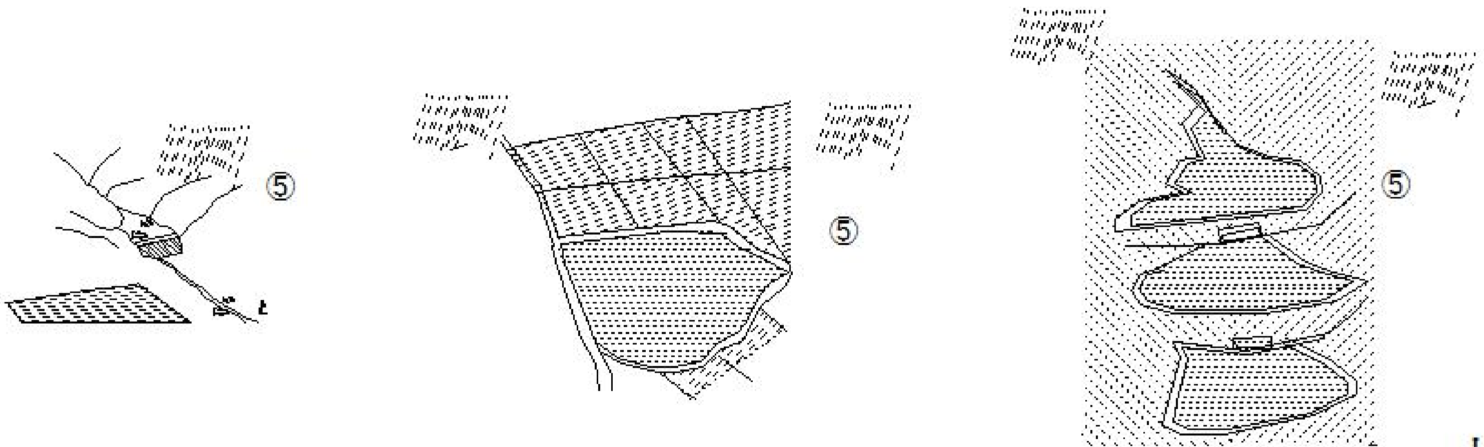
(I1459)Reservoir Management Manual

(I1459)Reservoir Management Manual

Reservoir Management Manual

Reservoir Condition Check

⑥ Has any part of the embankment subsided or protruded?



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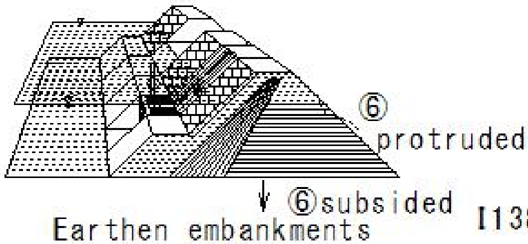

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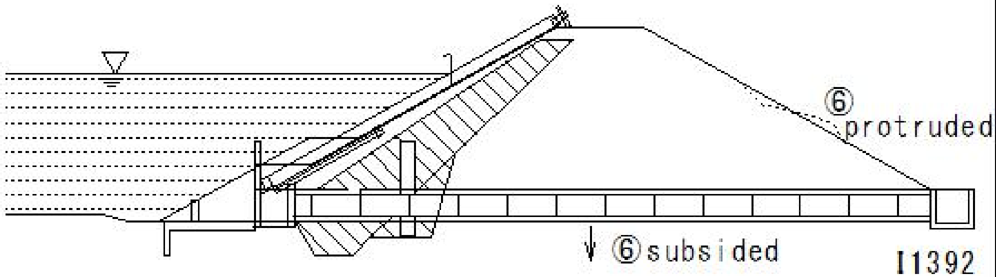


I1392

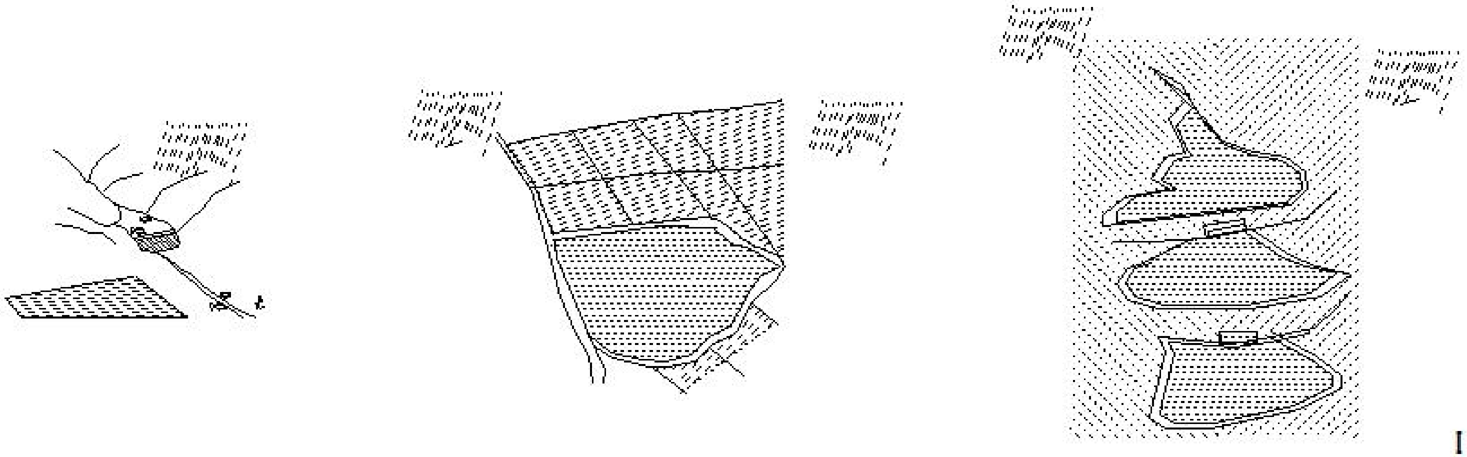
(I1460)Reservoir Management Manual

(I1460)Reservoir Management Manual

Reservoir Management Manual

Reservoir Condition Check

⑦ Are there any leaks around the drainpipes?



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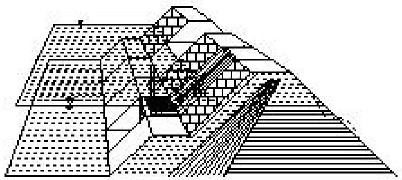

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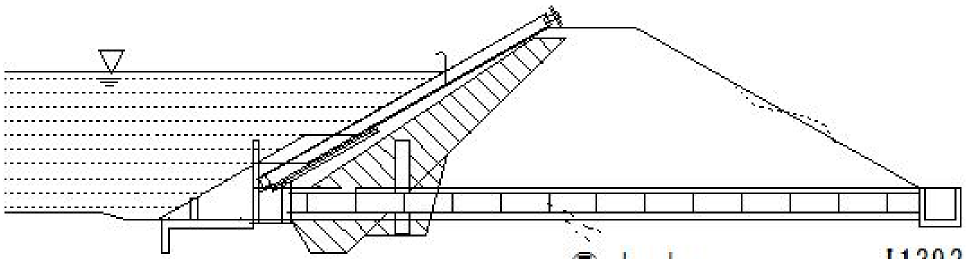


I1392

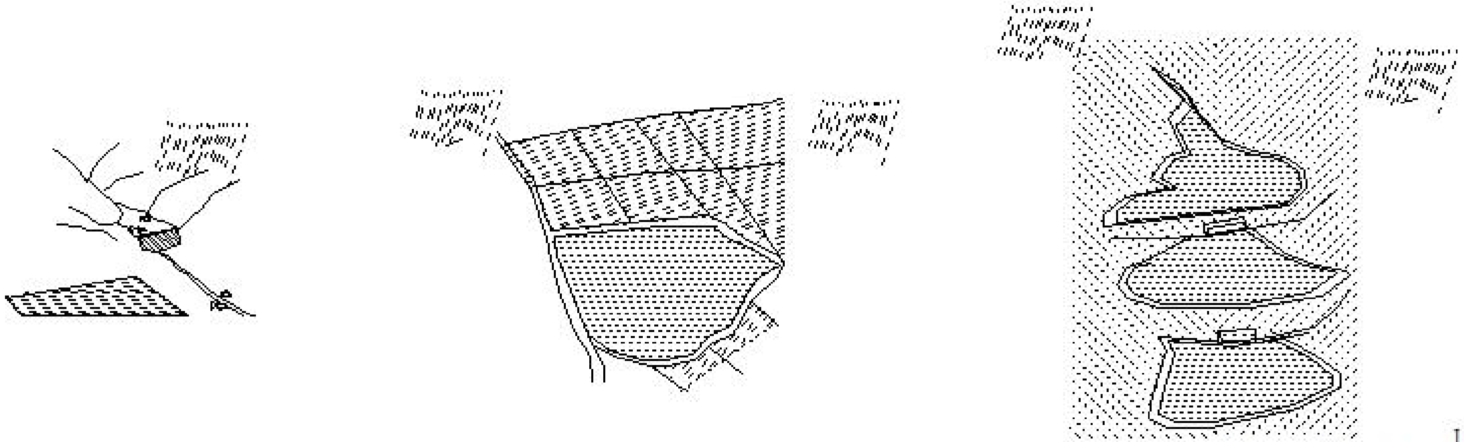
(I1461)Reservoir Management Manual

(I1461)Reservoir Management Manual

Reservoir Management Manual

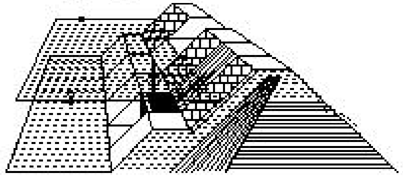
Reservoir Condition Check

⑧ Are the winding handles and gates working properly?



I1381

⑧ gates



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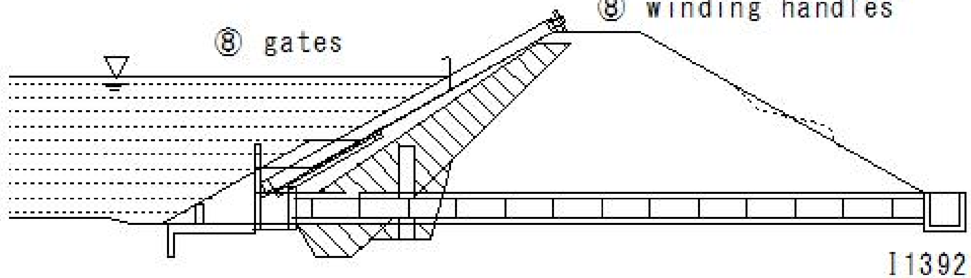
⑧ winding handles

⑧ gates



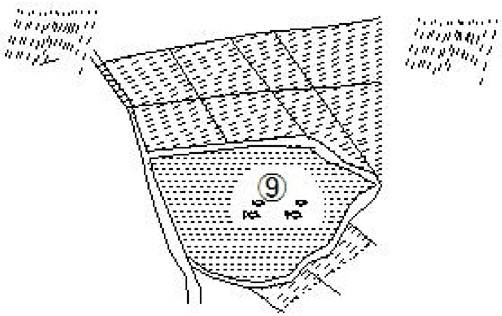
I1392

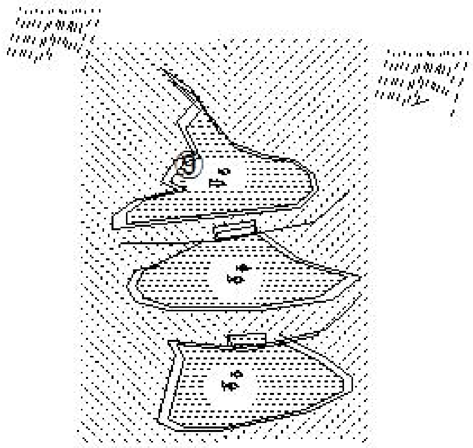
(I1462)Reservoir Management Manual

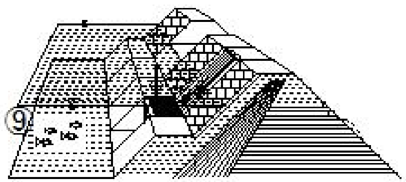
Reservoir Management Manual

Reservoir Condition Check

⑨ Do you know what creatures live in the reservoir?







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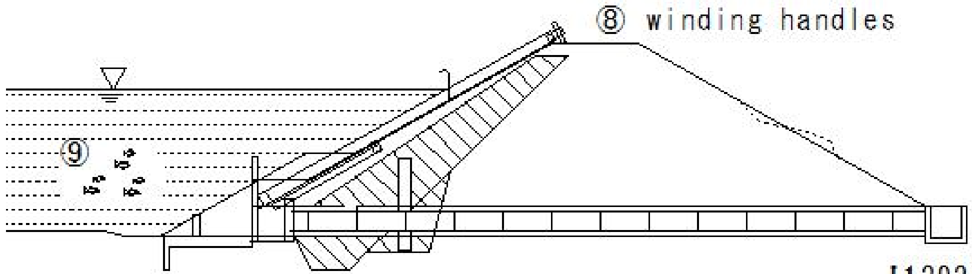


I1392

(I1463)Reservoir Management Manual

(I1463)Reservoir Management Manual

Main functions of reservoirs

①. Storing water for agricultural use: Storing water for agricultural use and replenishing it as needed

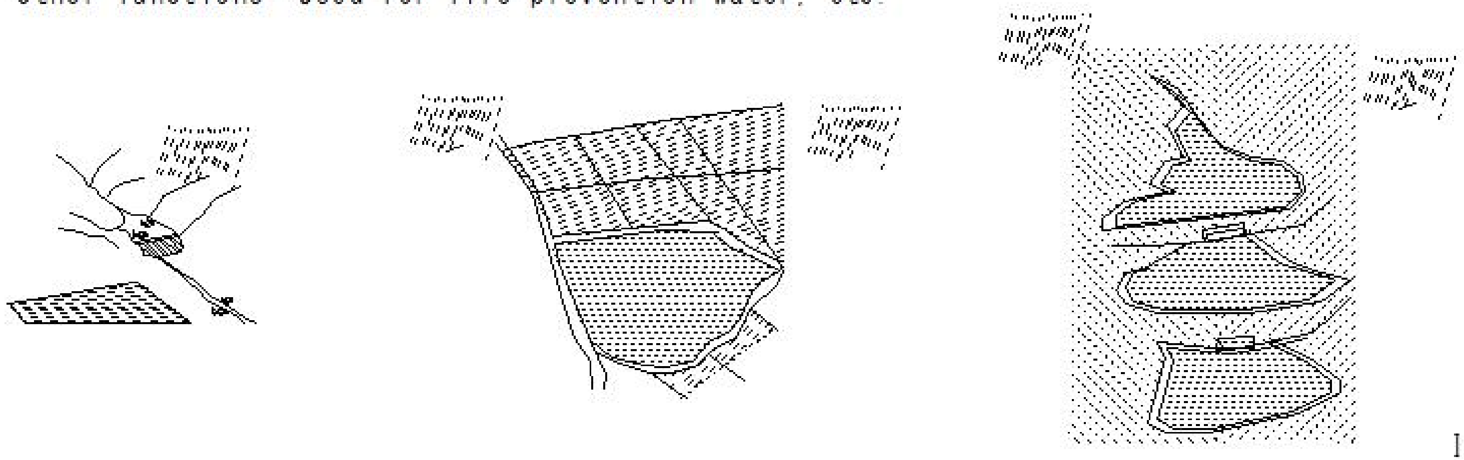
②. Flood control: Temporarily storing floodwaters during heavy rains

③. Preventing sediment runoff: Storing sediment and debris flowing from upstream

④. Preserving ecosystems: A habitat for aquatic plants, insects, etc.

⑤. Health and recreation: A place of relaxation for local people

⑥. Other functions: Used for fire prevention water, etc.



I1381

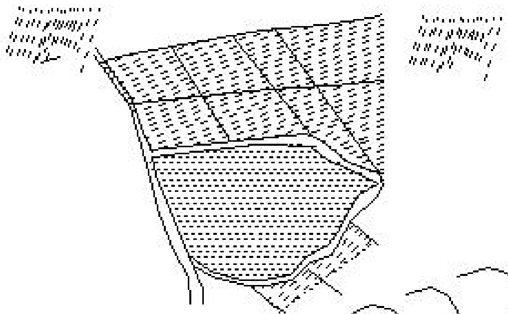
(I1464)Reservoir Management Manual

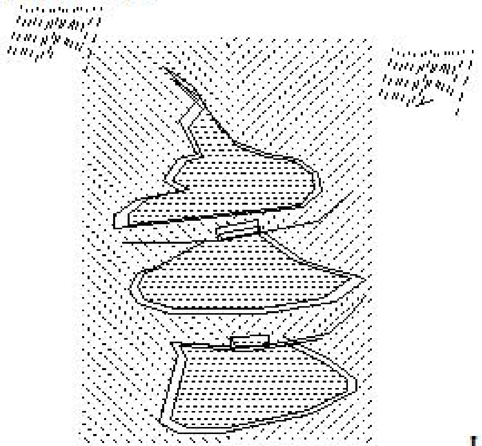
(I1464)Reservoir Management Manual

Main functions of reservoirs

①. Storing water for agricultural use: Storing water for agricultural use and replenishing it as needed

①.agricultural use





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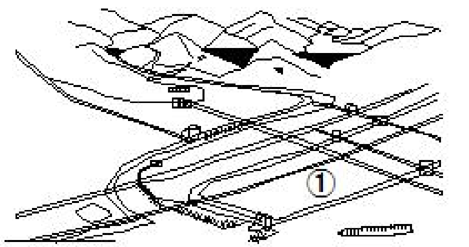
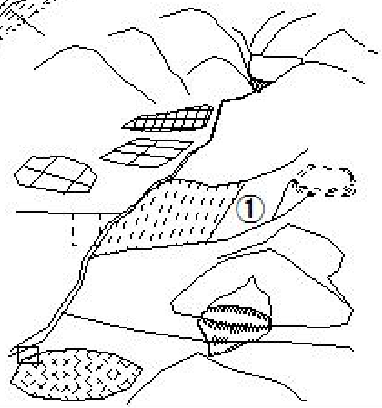


I994



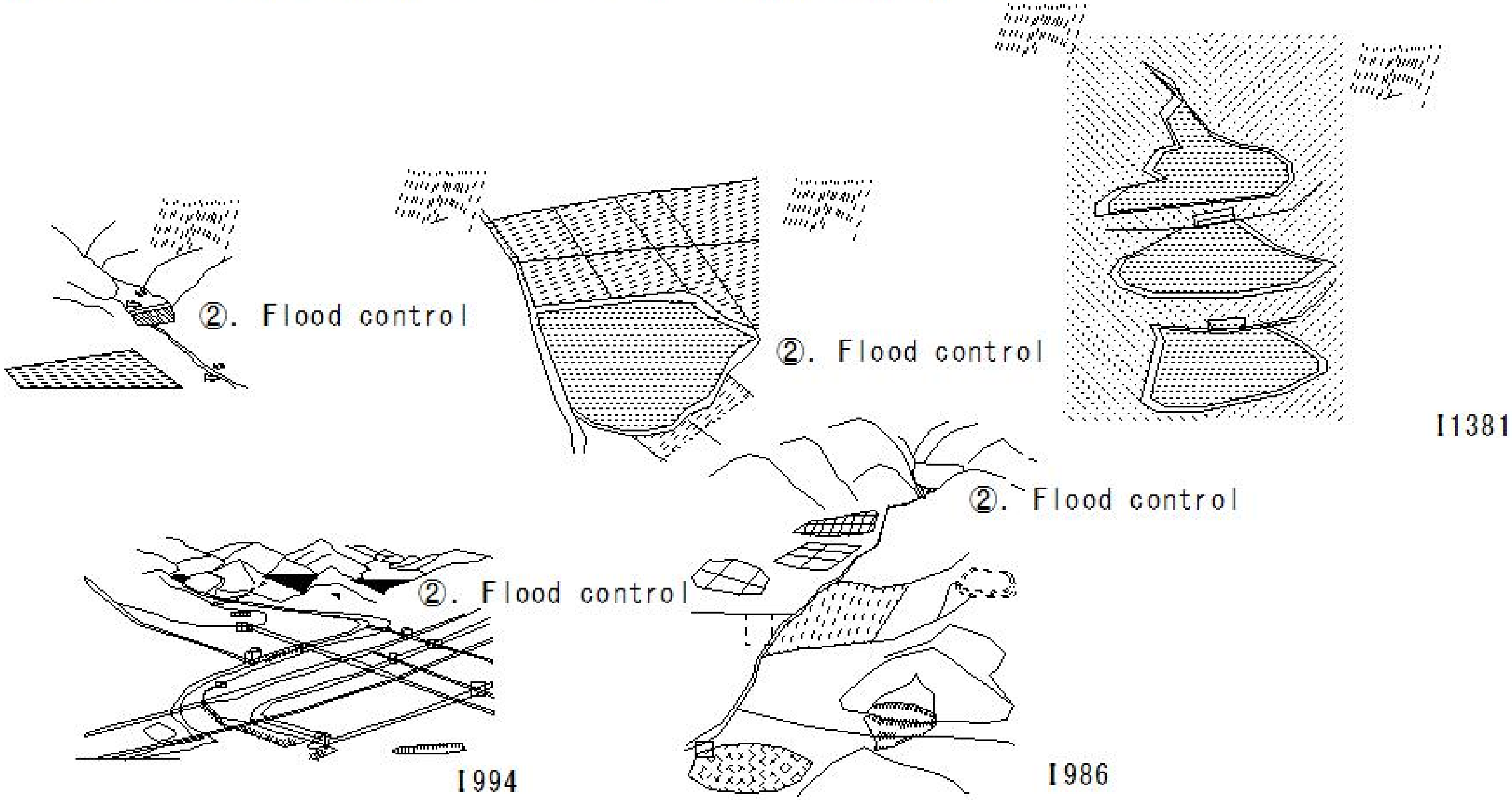
I986

(I1465)Reservoir Management Manual

(I1465)Reservoir Management Manual

Main functions of reservoirs

②. Flood control: Temporarily storing floodwaters during heavy rains

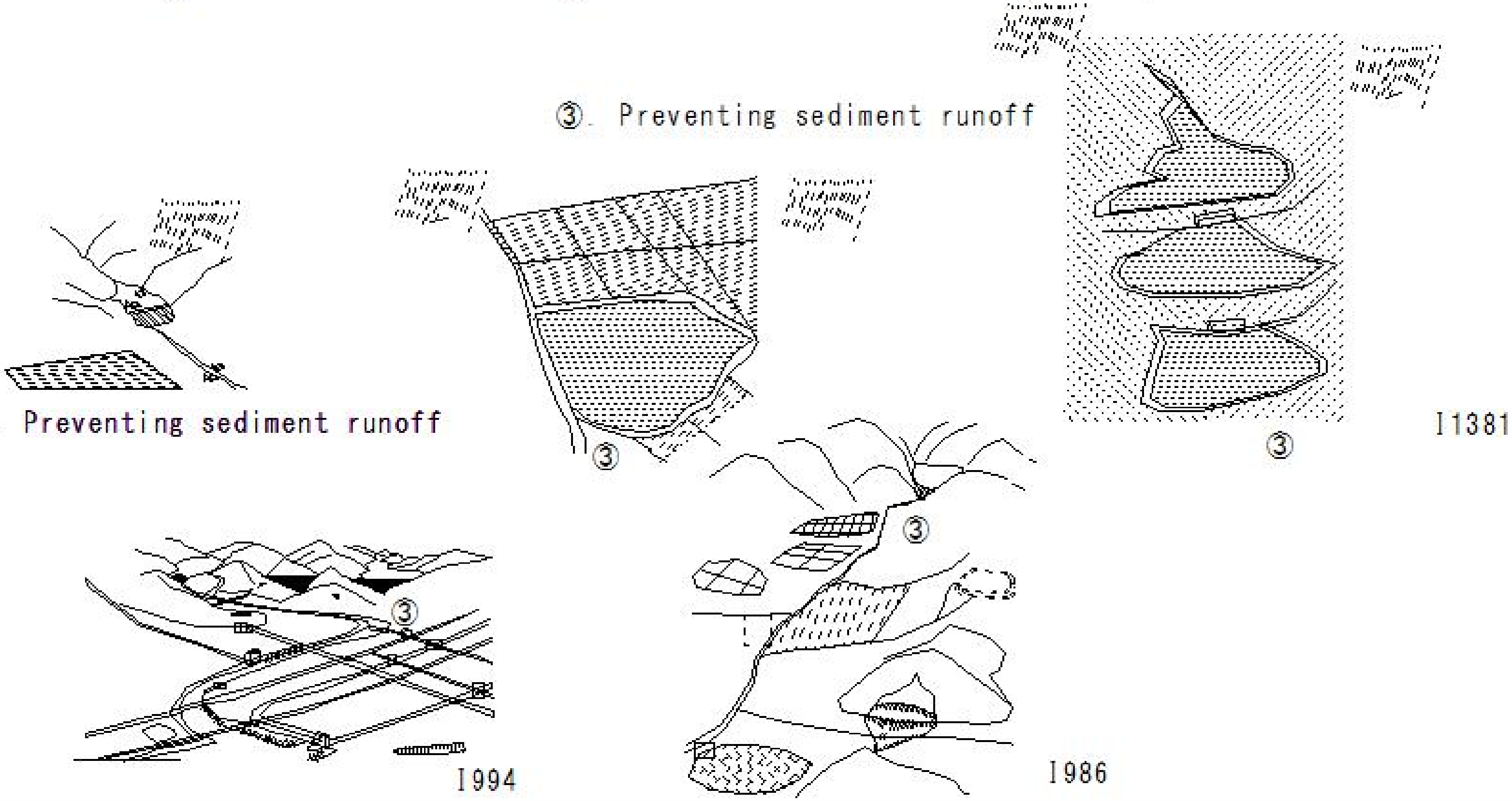


(I1466)Reservoir Management Manual

(I1466)Reservoir Management Manual

Main functions of reservoirs

③. Preventing sediment runoff: Storing sediment and debris flowing from upstream

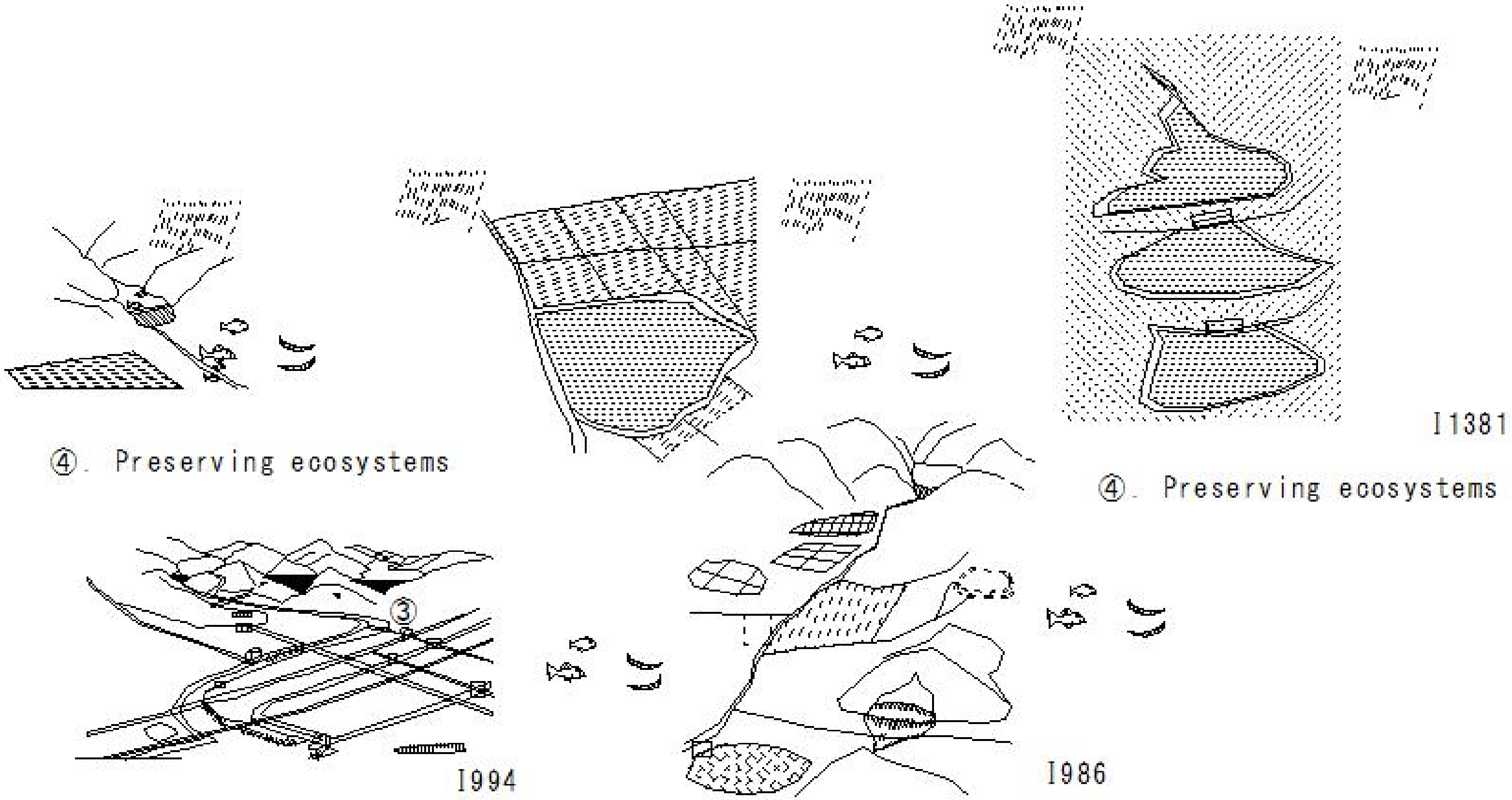


(I1467)Reservoir Management Manual

(I1467)Reservoir Management Manual

Main functions of reservoirs

④. Preserving ecosystems: A habitat for aquatic plants, insects, etc.

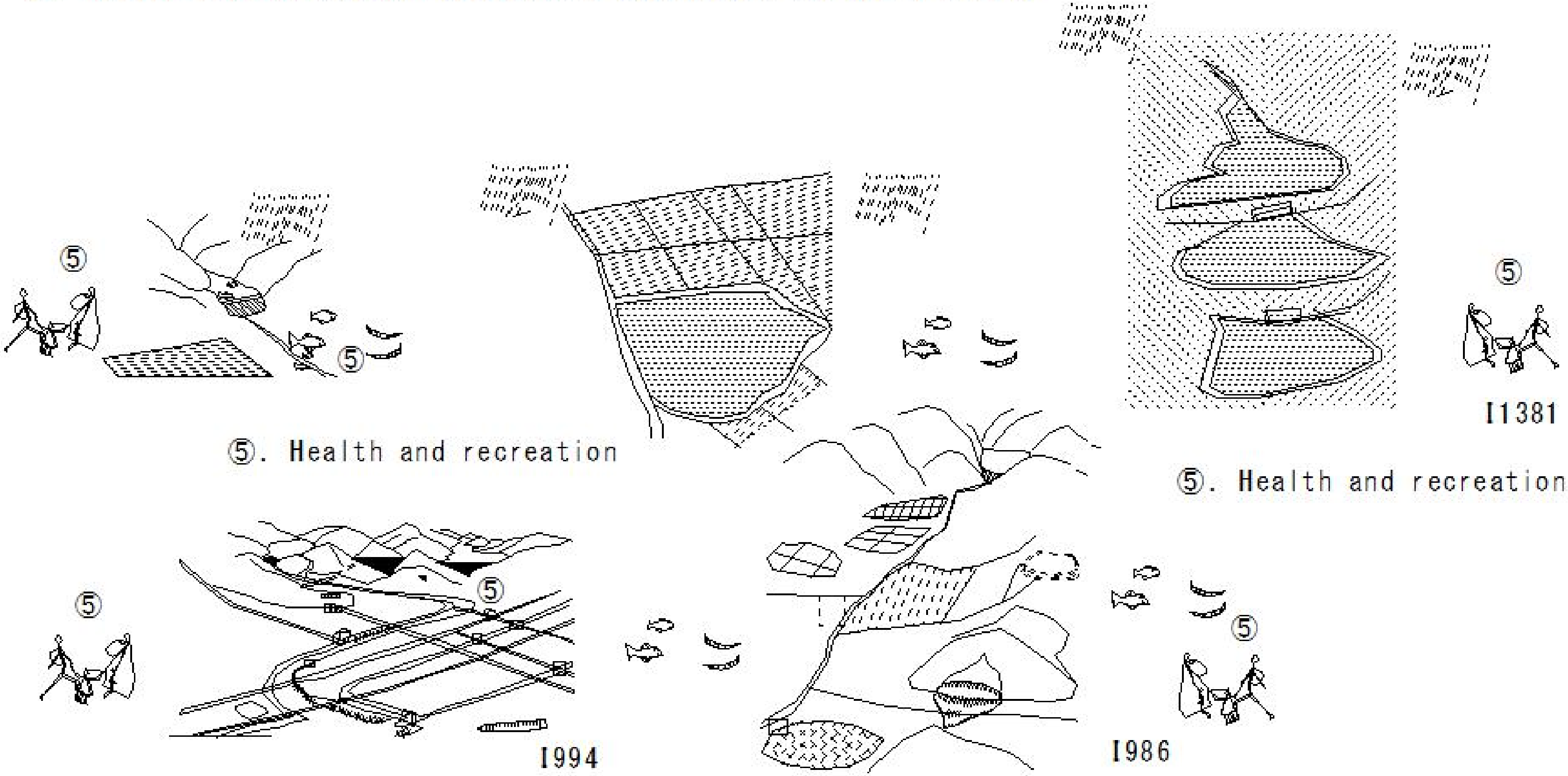


(I1468)Reservoir Management Manual

(I1468)Reservoir Management Manual

Main functions of reservoirs

⑤. Health and recreation: A place of relaxation for local people

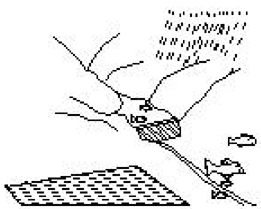


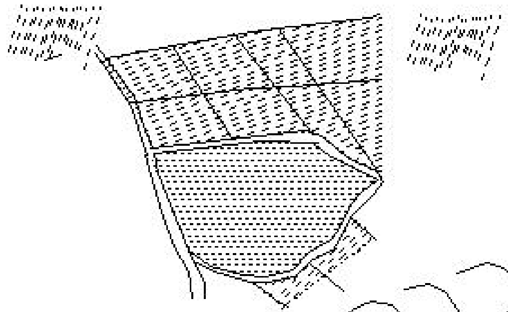
(I1469)Reservoir Management Manual

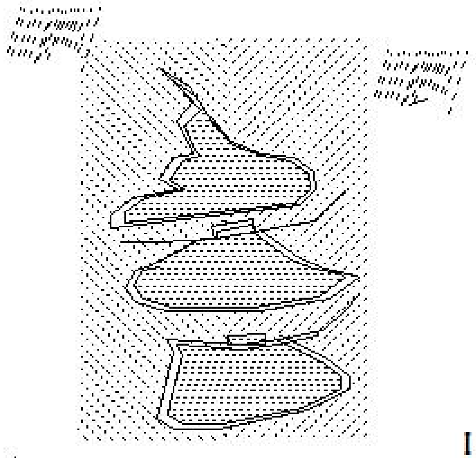
(I1469)Reservoir Management Manual

Main functions of reservoirs

⑥. Other functions: Used for fire prevention water, etc.







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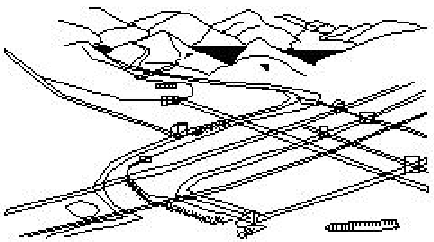
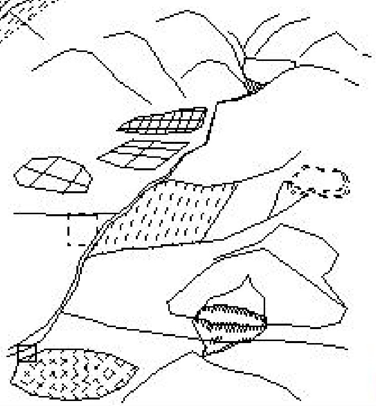




I986

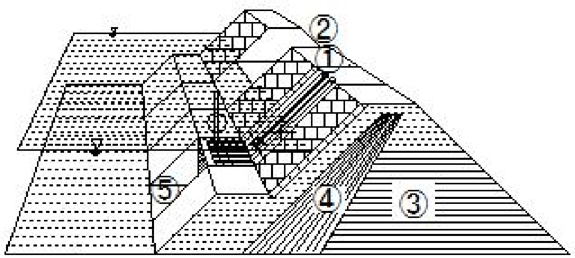
⑥. fire prevention water I994

(I1470)Reservoir Management Manual

(I1470)Reservoir Management Manual

Structure of the reservoir

① Water intake facility (inclined gutter)
② Floodway
③ Embankment
④ Water-shielding zone
⑤ Water intake facility (bottom gutter)



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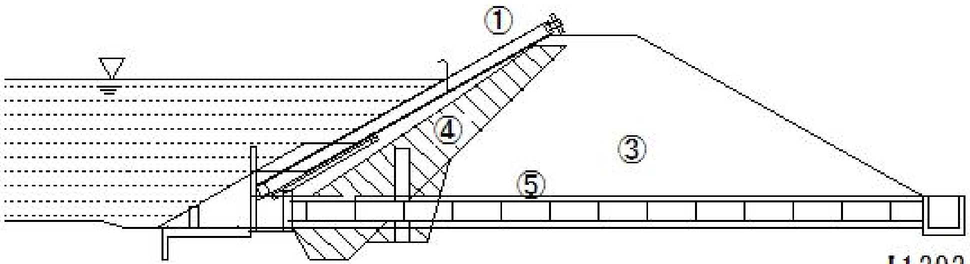

I1392

(I1471)Reservoir Management Manual

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Reservoir structure

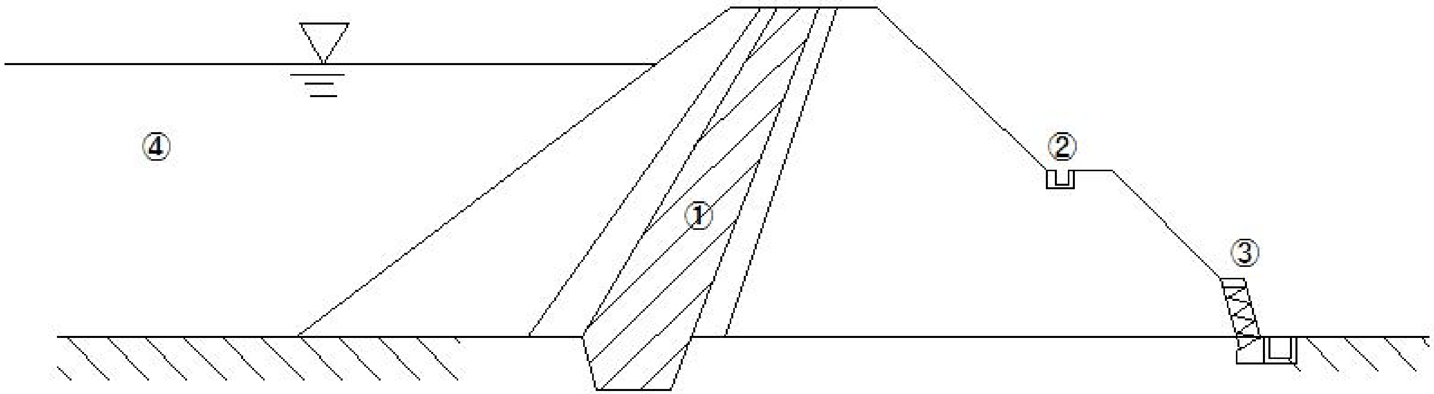
○ Embankment

① Water-shielding zone

② Water receiving channel

③ End drain

④ Reservoir



Cross-section of reservoir

(I1472)Reservoir Management Manual

(I1472)Reservoir Management Manual

Reservoir structure

○ Embankment① Water-shielding zone ② Water receiving channel ③ End drain ④ Reservoir

Embankment

a The embankment of a reservoir is a civil engineering structure that crosses a river or valley and is made by piling up soil.

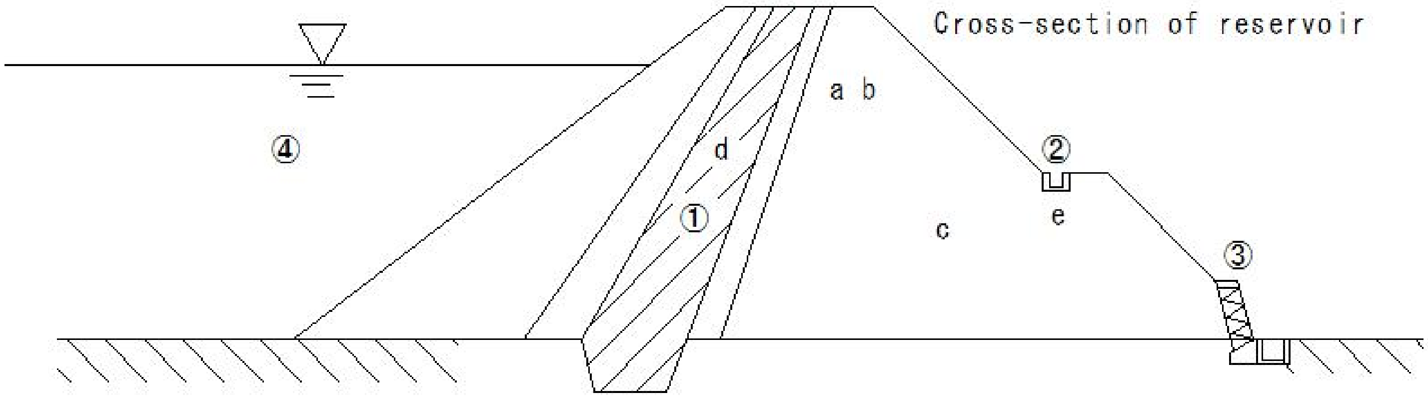
b It blocks water flowing from upstream and stores it in a space (reservoir) surrounded by the embankment and the ground upstream of the embankment.

c It is made by compacting soil with a high fine grain content.

d A layer of compacted soil (water-blocking zone) made of clay-rich soil that is difficult for water to pass through is placed in part of the embankment.

e A waterway (water-receiving channel) is provided on the berm downstream of the embankment to drain rain that falls on the embankment slope.

Cross-section of reservoir



(I1473)Reservoir Management Manual

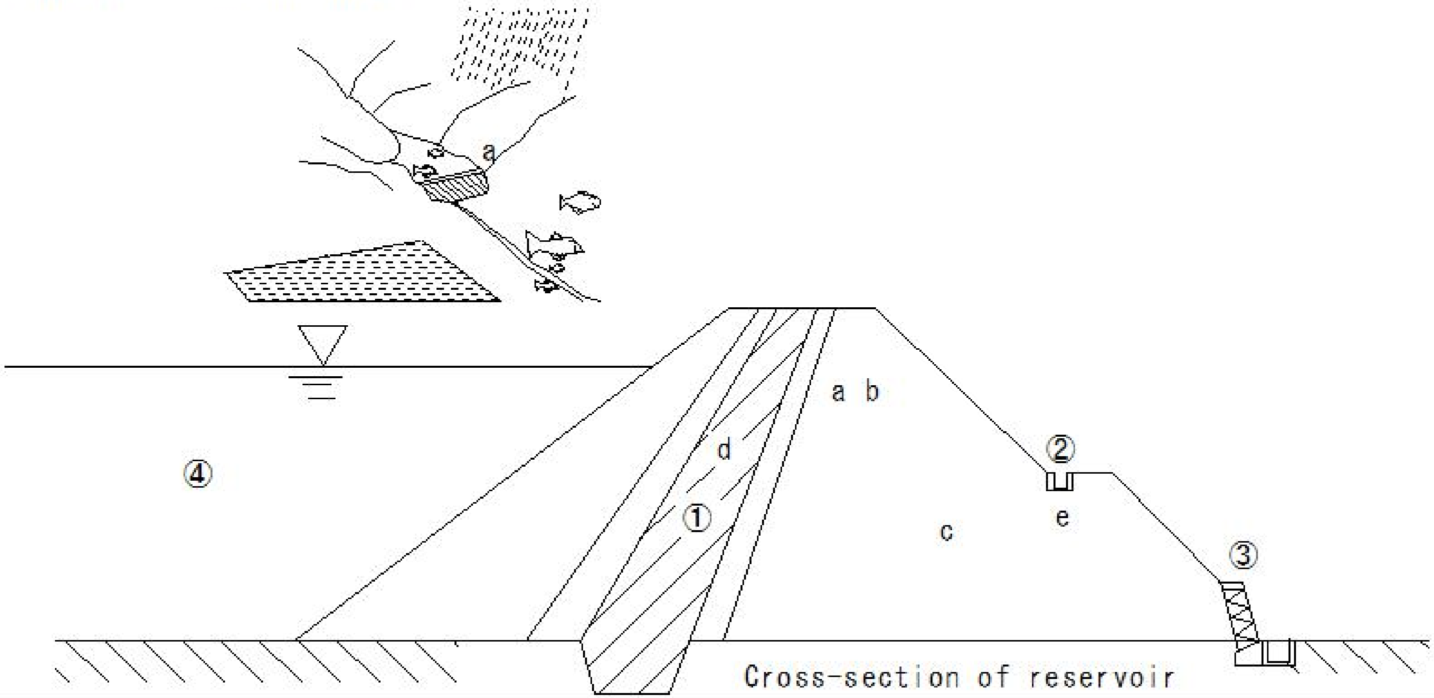
(I1473)Reservoir Management Manual

Reservoir structure

○ Embankment① Water-shielding zone ② Water receiving channel ③ End drain ④ Reservoir

Embankment

a The embankment of a reservoir is a civil engineering structure that crosses a river or valley and is made by piling up soil.



Cross-section of reservoir

(I1474)Reservoir Management Manual

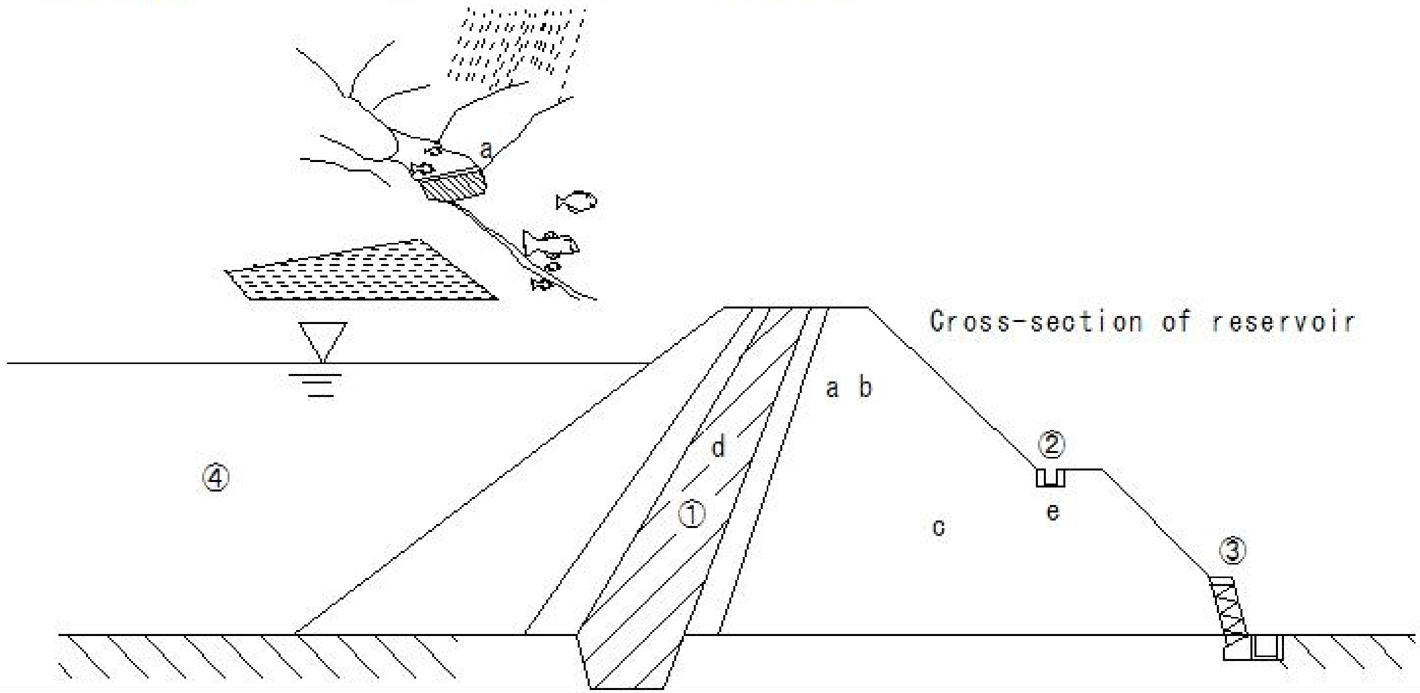
(I1474)Reservoir Management Manual

Reservoir structure

○ Embankment① Water-shielding zone ② Water receiving channel ③ End drain ④ Reservoir

Embankment

b It blocks water flowing from upstream and stores it in a space (reservoir) surrounded by the embankment and the ground upstream of the embankment.



(I1475)Reservoir Management Manual

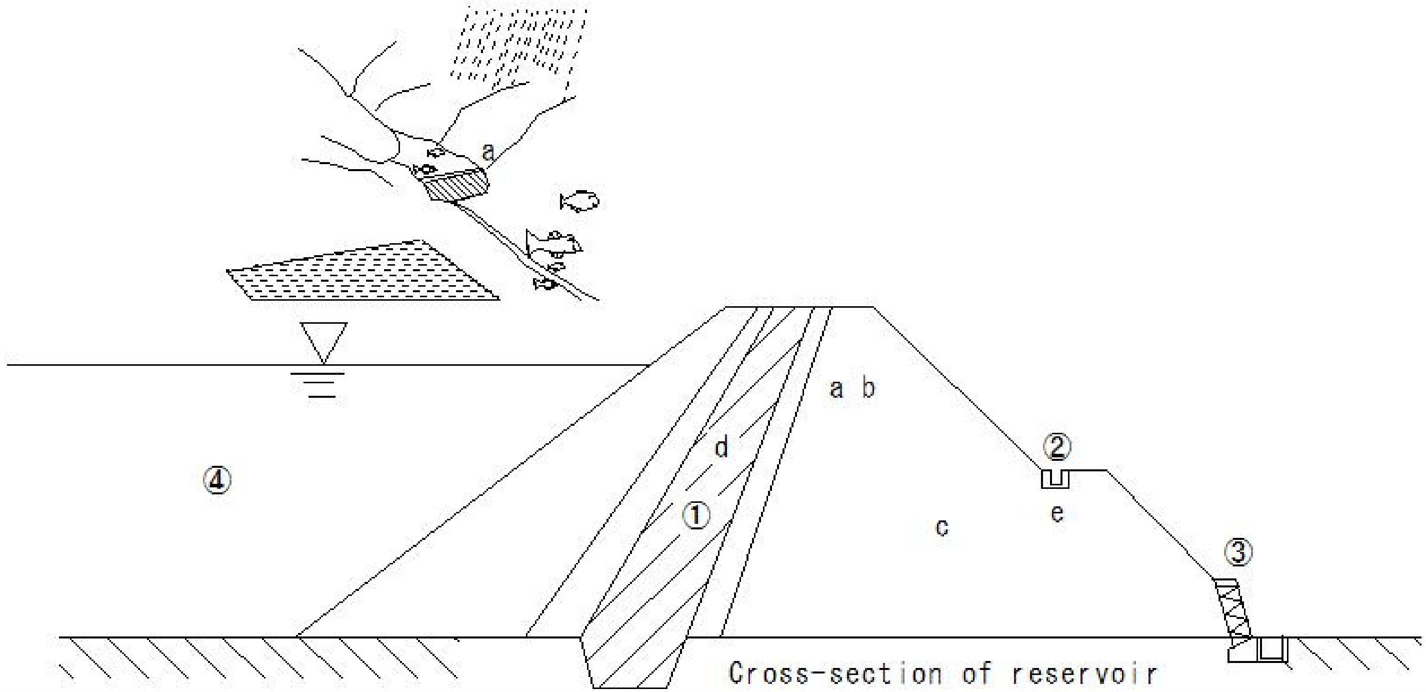
(I1475)Reservoir Management Manual

Reservoir structure

○ Embankment① Water-shielding zone ② Water receiving channel ③ End drain ④ Reservoir

Embankment

c It is made by compacting soil with a high fine grain content.



(I1476)Reservoir Management Manual

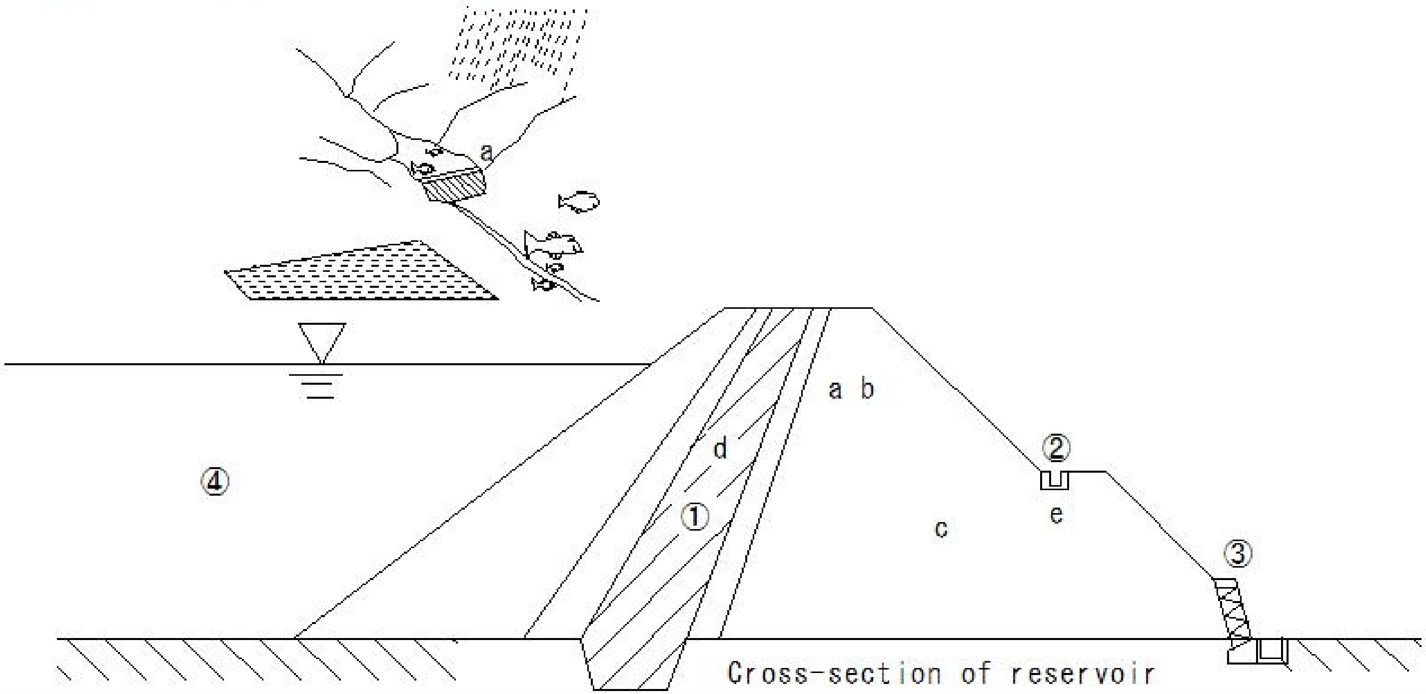
(I1476)Reservoir Management Manual

Reservoir structure

○ Embankment① Water-shielding zone ② Water receiving channel ③ End drain ④ Reservoir

Embankment

d A layer of compacted soil (water-blocking zone) made of clay-rich soil that is difficult for water to pass through is placed in part of the embankment.



Cross-section of reservoir

(I1477)Reservoir Management Manual

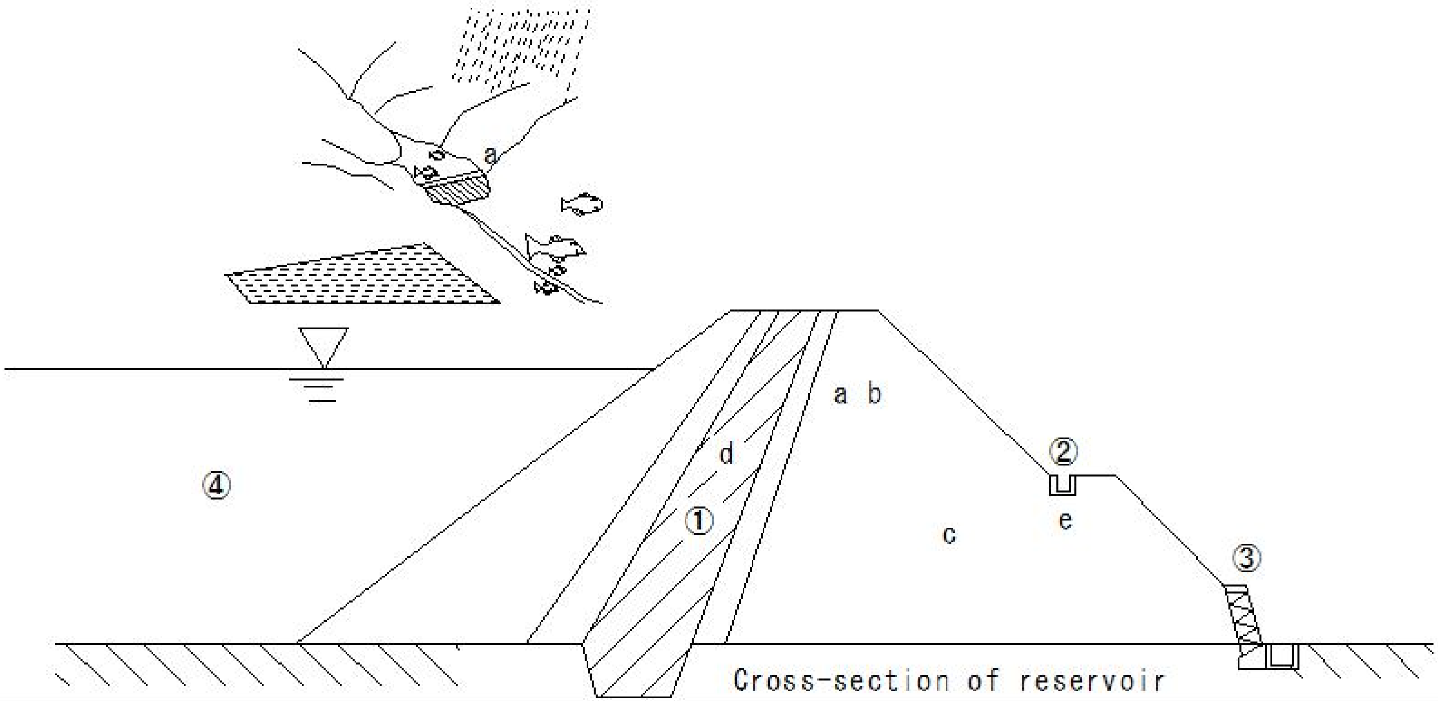
(I1477)Reservoir Management Manual

Reservoir structure

○ Embankment① Water-shielding zone ② Water receiving channel ③ End drain ④ Reservoir

Embankment

e A waterway (water-receiving channel) is provided on the berm downstream of the embankment to drain rain that falls on the embankment slope.



Cross-section of reservoir

(I1478)Reservoir Management Manual

(I1478)Reservoir Management Manual

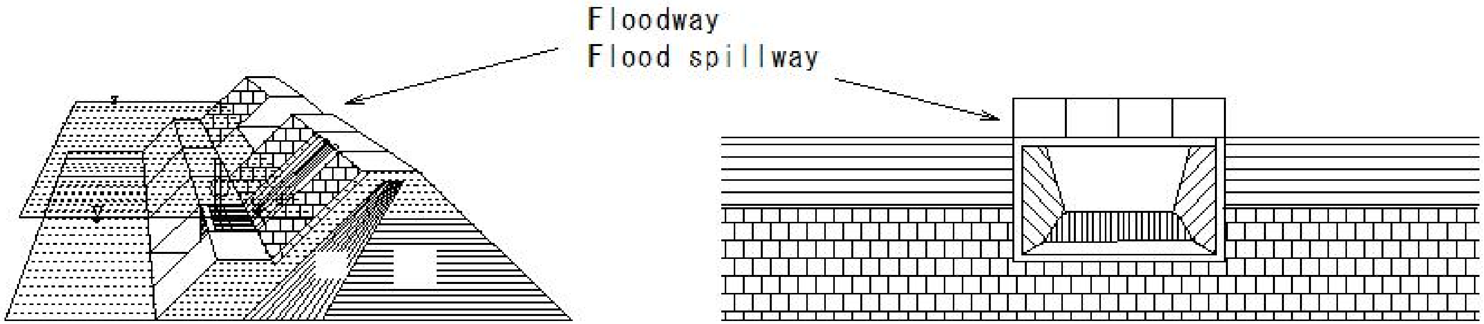
Structure of the reservoir

○ Floodway

Flood spillway

a To prevent stored water from overflowing the embankment during heavy rains

b A facility to safely drain water that has flowed into a reservoir



I1383

(I1479)Reservoir Management Manual

(I1479)Reservoir Management Manual

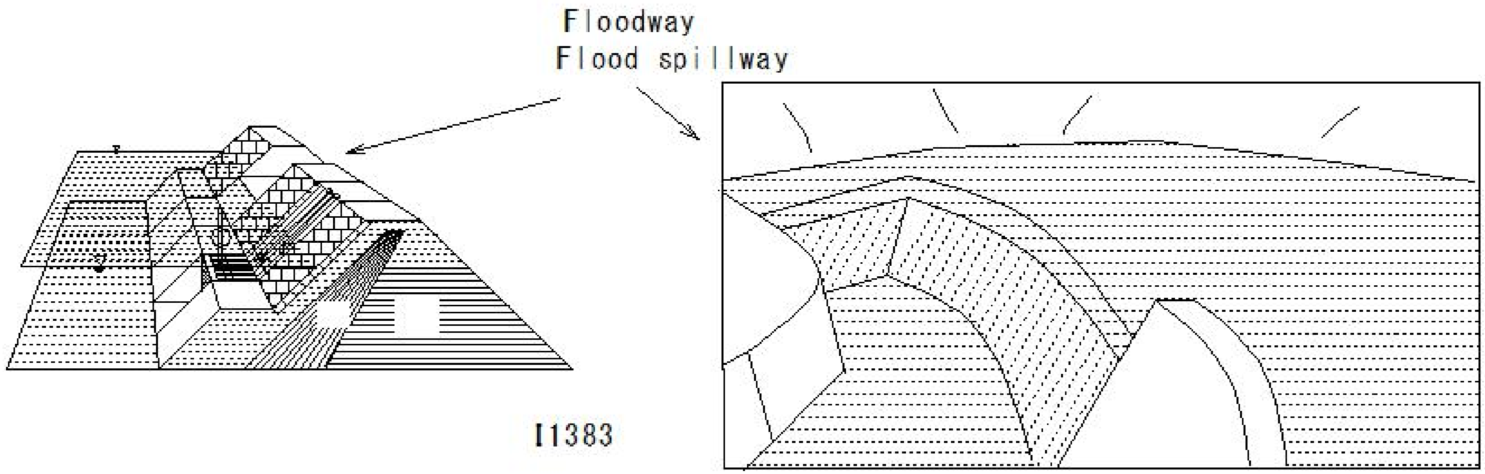
Structure of the reservoir

○ Floodway

Flood spillway

a To prevent stored water from overflowing the embankment during heavy rains

b A facility to safely drain water that has flowed into a reservoir



I1383

(I1480)Reservoir Management Manual

(I1480)Reservoir Management Manual

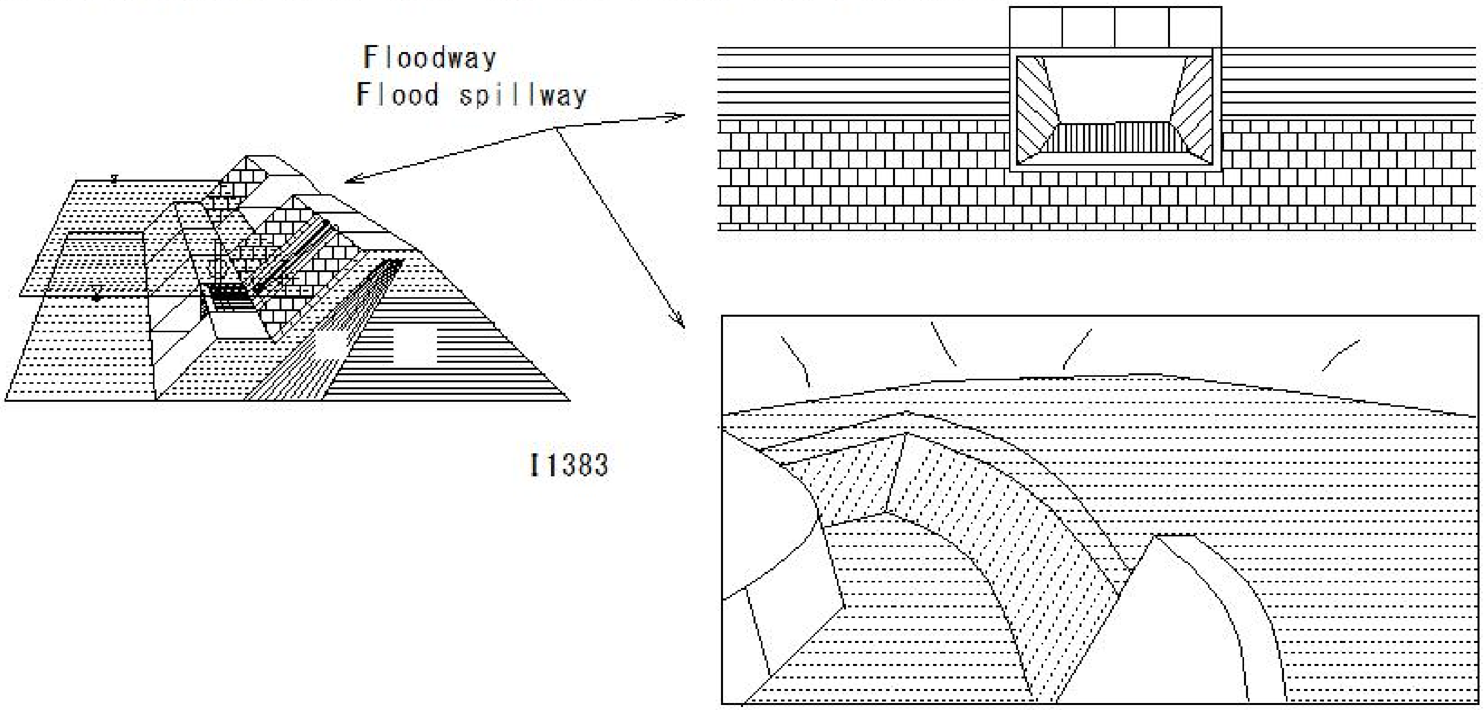
Structure of the reservoir

○ Floodway

Flood spillway

a To prevent stored water from overflowing the embankment during heavy rains

b A facility to safely drain water that has flowed into a reservoir



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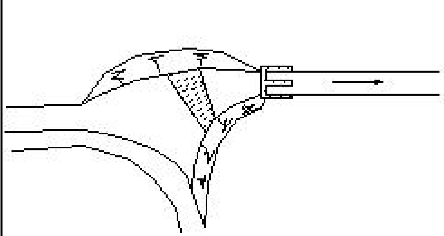
○ Floodway Flood spillway



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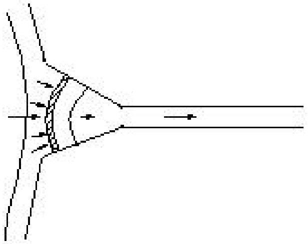

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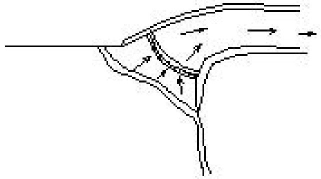

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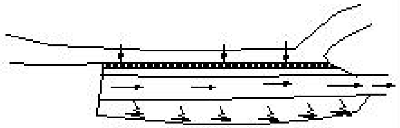

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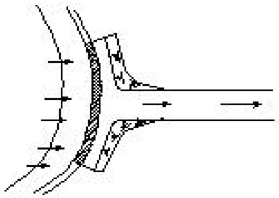

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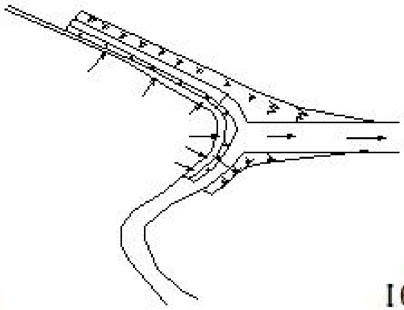

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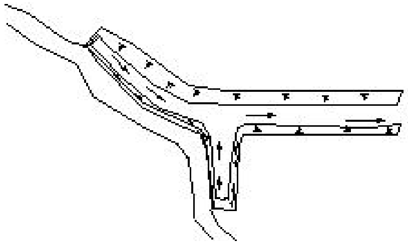

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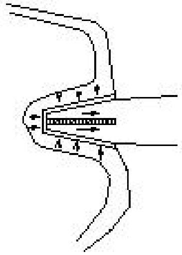

I71

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Structure of the reservoir

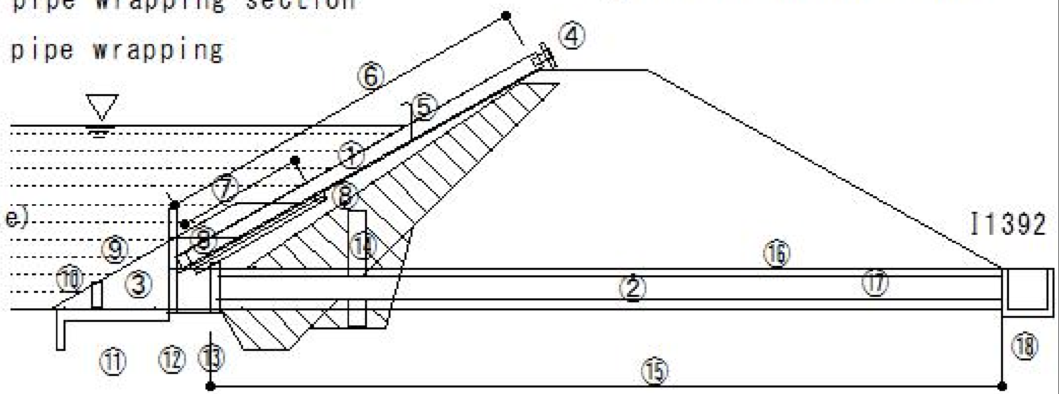
Water intake facility

a Water from the reservoir is taken in through the intake hole and sent to the irrigation channel through the inclined pipe and bottom pipe.

b The inclined pipe is usually divided into several stages and has intake gates or plugs installed, so that warm water near the water surface can be taken in depending on the water level.

c The bottom pipe is the passageway for the irrigation water taken in from the inclined pipe, and is located at the bottom of the reservoir and also serves as a drainage facility to empty the reservoir.

① Inclined gutter
② Bottom gutter
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gate
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work



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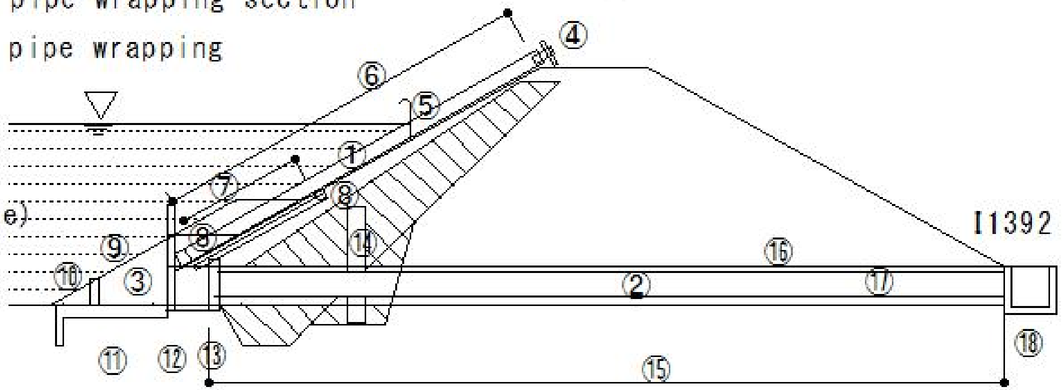
(I1483)Reservoir Management Manual

Structure of the reservoir

Water intake facility

① Inclined gutter
② Bottom gutter
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gate
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work



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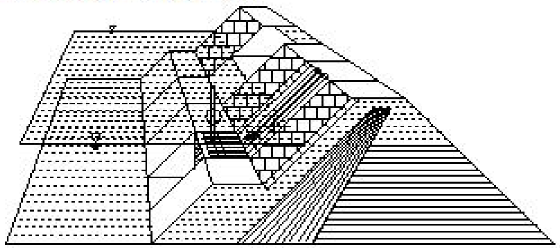

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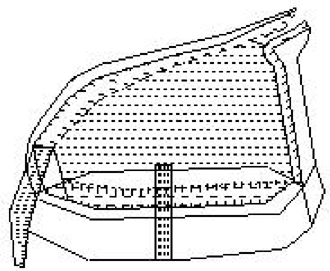

I1386

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Structure of the reservoir

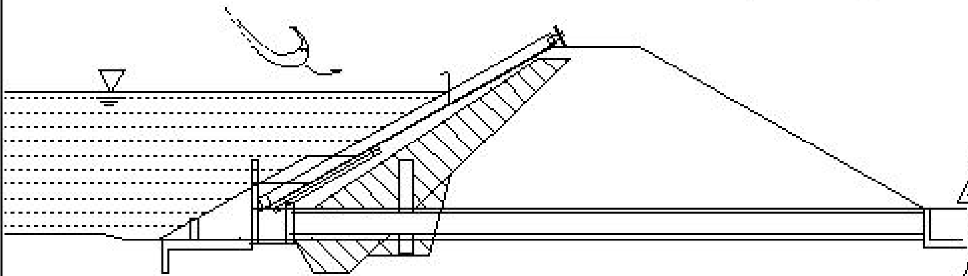
Stone covering (block covering, etc.) stone pitching work

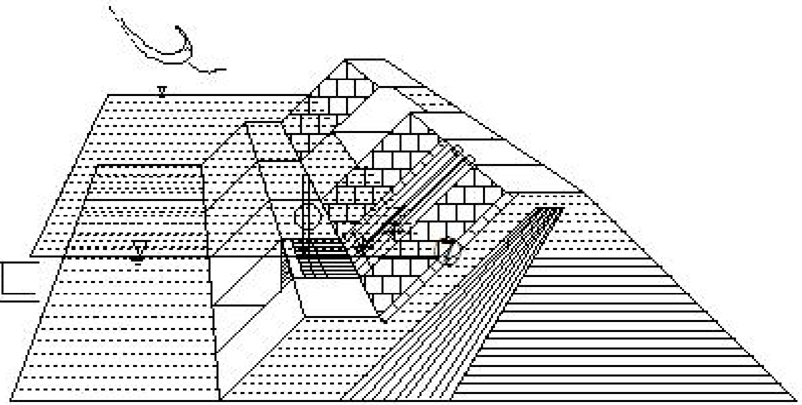
a Reservoirs are built in areas that are easy to dam up water flowing from mountains and valleys
b These areas are also prone to strong winds

c In case of strong winds blow over the reservoir water surface, waves are generated
d The earthen embankment is eroded

e Stone covering (block covering, etc.) is installed

Block pitching
Stone pitching





stone pitching work
・Embankment slope
・Slope protection

I1392

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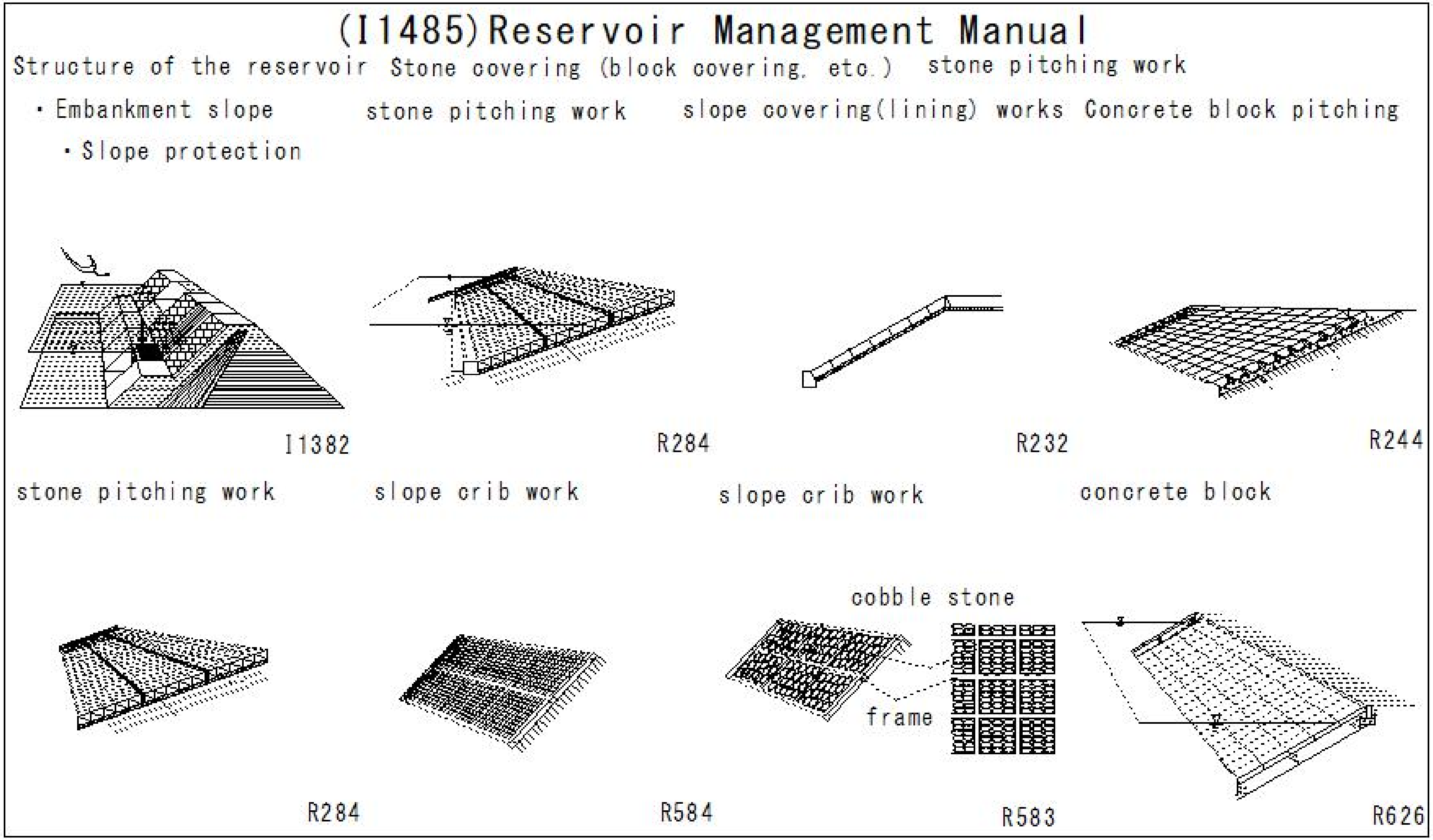

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○ Mechanism of reservoir collapse due to heavy rain and earthquakes

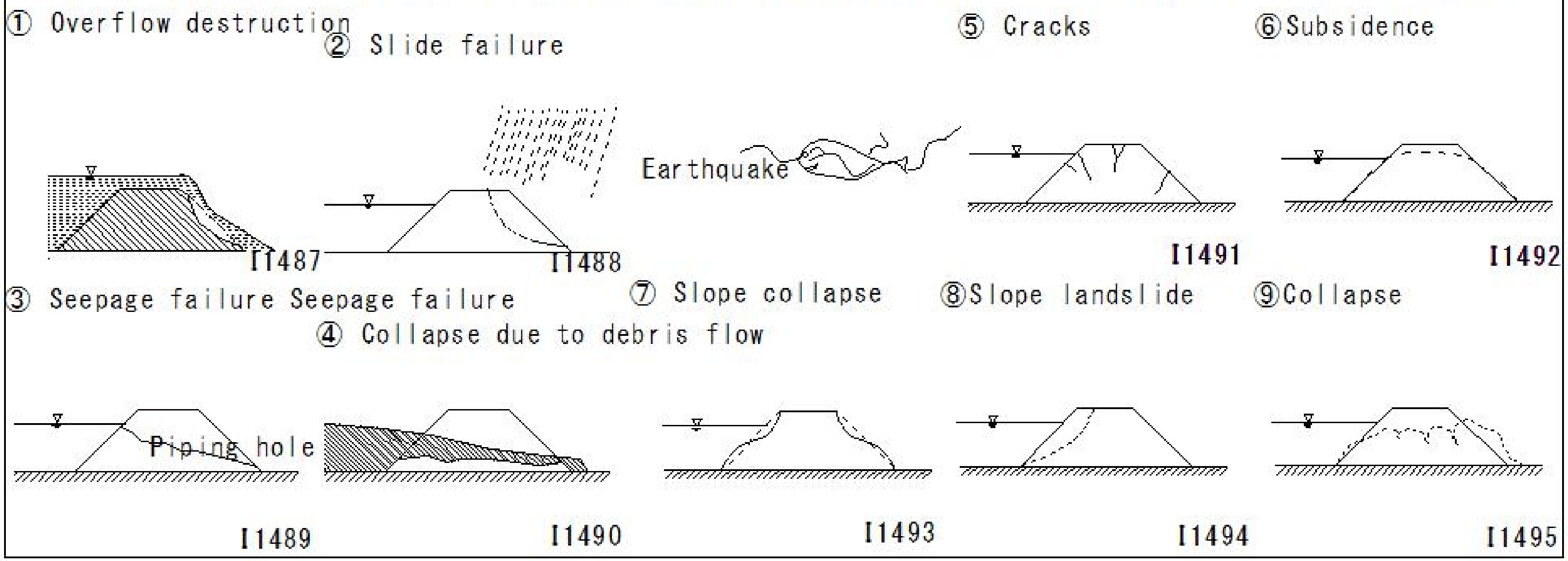
① During heavy rain, a large amount of rainwater flows into the reservoir, and the stored water overflows the embankment

② The overflowing water erodes the embankment, which is very dangerous

③ In case of a large amount of rainwater seeps into the downstream slope, it may collapse.

④ During an earthquake, the strength of the soil decreases due to shaking

⑤ The embankment may collapse due to the collapse of the slope or the sinking of the embankment.



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○Mechanism of reservoir collapse due to heavy rain and earthquakes

○ Damage type

① Overflow destruction

○ Damage mechanism

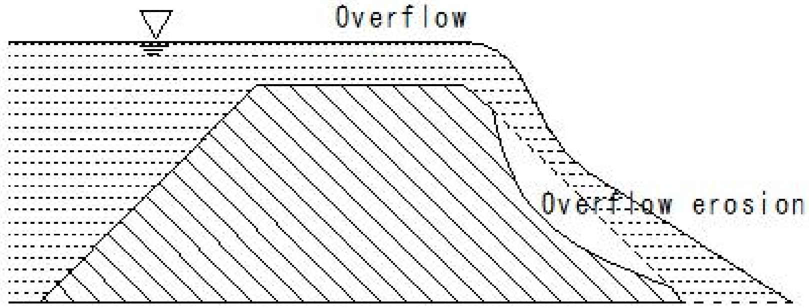
a In case of the reservoir water level rises suddenly due to rain or blockage of the spillway and overflows the levee.

b It may be destroyed by eroding the downstream slope.

c As the reservoir water level rises, the water pressure inside the levee also increases.

d It may be destroyed by a decrease in strength.

① Overflow destruction



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○Mechanism of reservoir collapse due to heavy rain and earthquakes

○ Damage type

② Slide failure

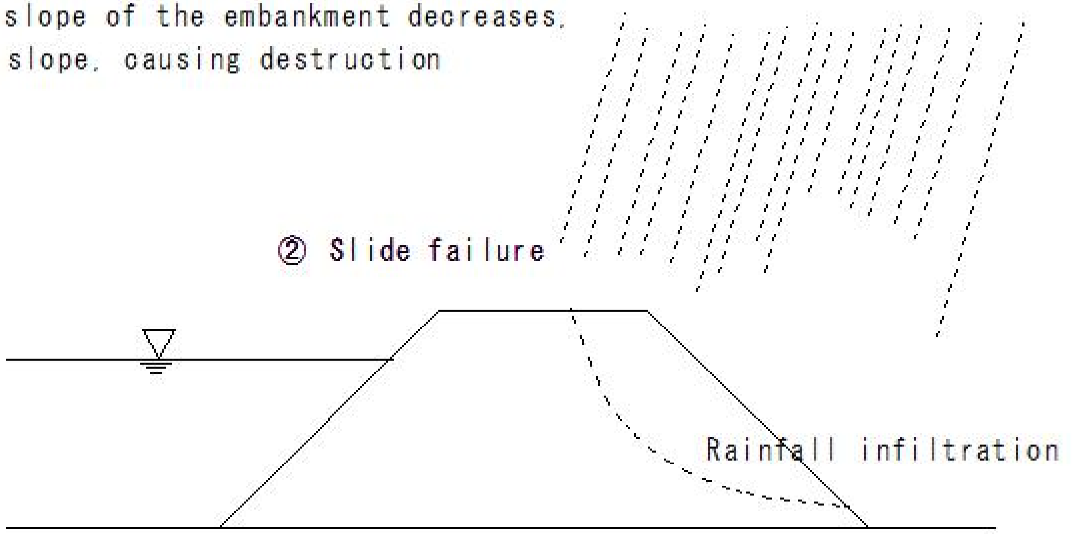
○ Damage mechanism

② Rainfall infiltration.

a The stored water and rainfall infiltrate into the embankment, increasing the amount of water inside the embankment.

b The strength of the slope of the embankment decreases.

c Slide occurs on the slope, causing destruction



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○Mechanism of reservoir collapse due to heavy rain and earthquakes

○ Damage type

③ Seepage failure Seepage failure

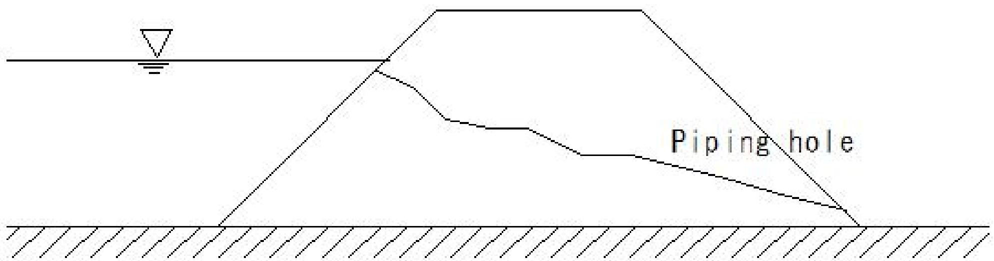
○ Damage mechanism

a The inside of the embankment deteriorates, reducing its ability to block water

b In case of the reservoir water level rises, the water pressure inside the embankment also increases, reducing its strength and causing it to break

c A water path is formed inside the embankment that runs from upstream to downstream, causing it to break

③ Seepage failure Seepage failure



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○Mechanism of reservoir collapse due to heavy rain and earthquakes

○ Damage type

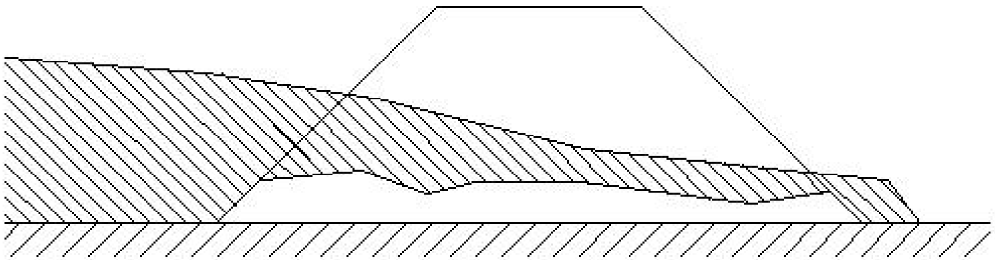
④ Collapse due to debris flow

○ Damage mechanism

a Debris flow caused by the collapse of forests in the upstream area

b The embankment may be destroyed.

④ Collapse due to debris flow



(I1491)Reservoir Management Manual

(I1491)Reservoir Management Manual

<Mechanism of damage to reservoirs caused by earthquakes>

○ Damage type

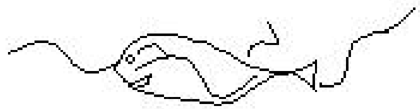
⑤ Cracks

○ Damage mechanism

a Cracks may occur on the top of the embankment.

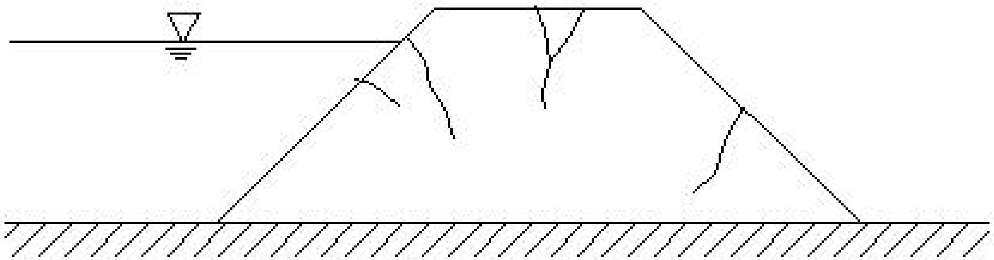
b Cracks that occur upstream and downstream of the embankment may become water channels.

c Particular attention is required.



Earthquake

⑤ Cracks



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〈Mechanism of damage to reservoirs caused by earthquakes〉

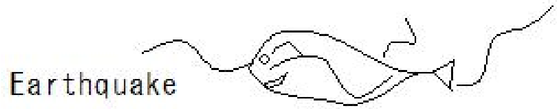
○ Damage type

⑥Subsidence

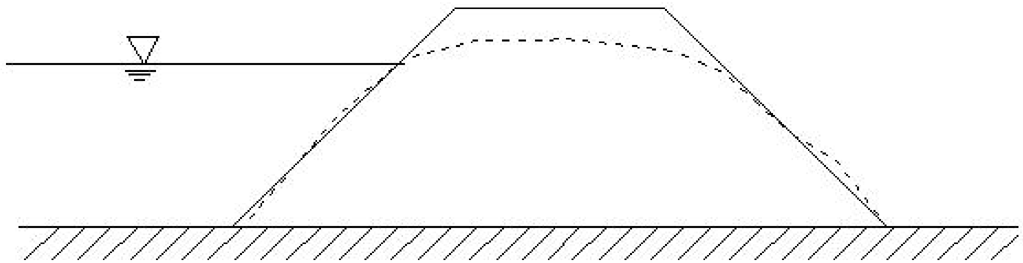
○ Damage mechanism

a The embankment may sink while retaining most of its shape and exhibiting cracks.

b Most of the damage occurs on soft ground.



⑥Subsidence



(I1493)Reservoir Management Manual

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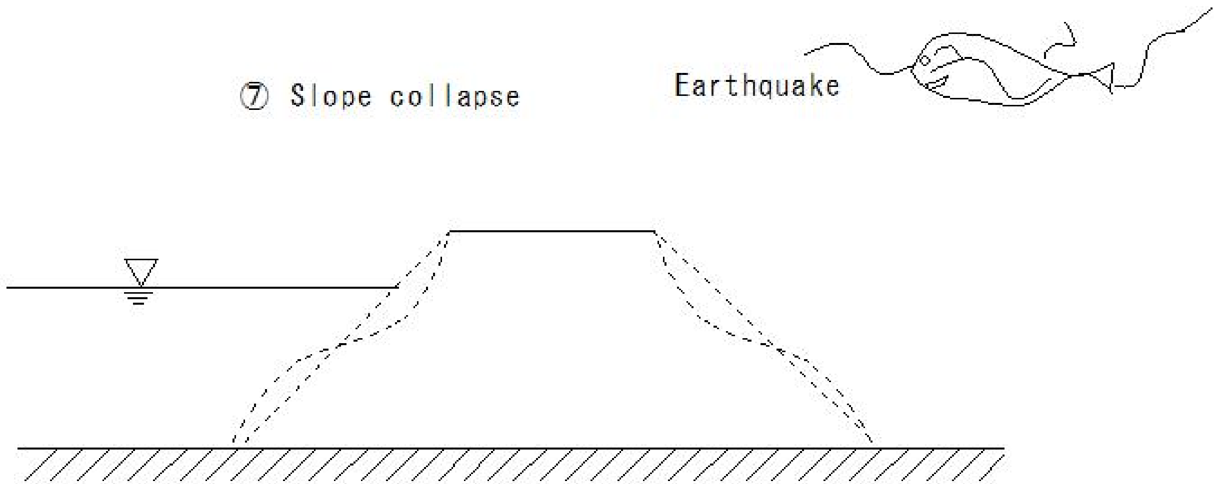
<Mechanism of damage to reservoirs caused by earthquakes>

○ Damage type

⑦ Slope collapse

○ Damage mechanism

a The upper part of the embankment slope may sink and the lower part may swell, causing deformation.



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(I1494)Reservoir Management Manual

<Mechanism of damage to reservoirs caused by earthquakes>

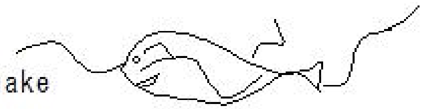
○ Damage type

⑧Slope landslide

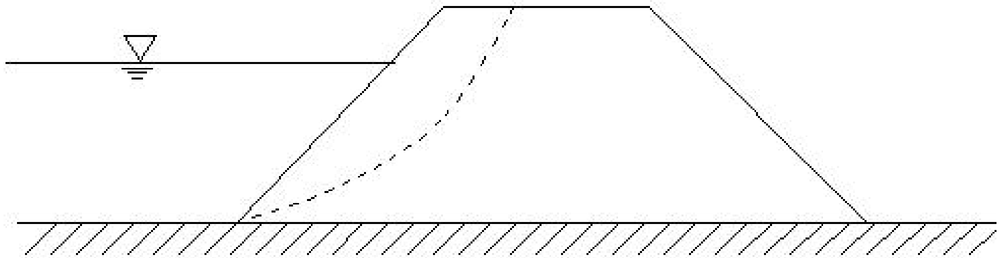
○ Damage mechanism

a Seismic motion may cause the slope of the embankment to slide.

Earthquake



⑧Slope landslide



(I1495)Reservoir Management Manual

(I1495)Reservoir Management Manual

<Mechanism of damage to reservoirs caused by earthquakes>

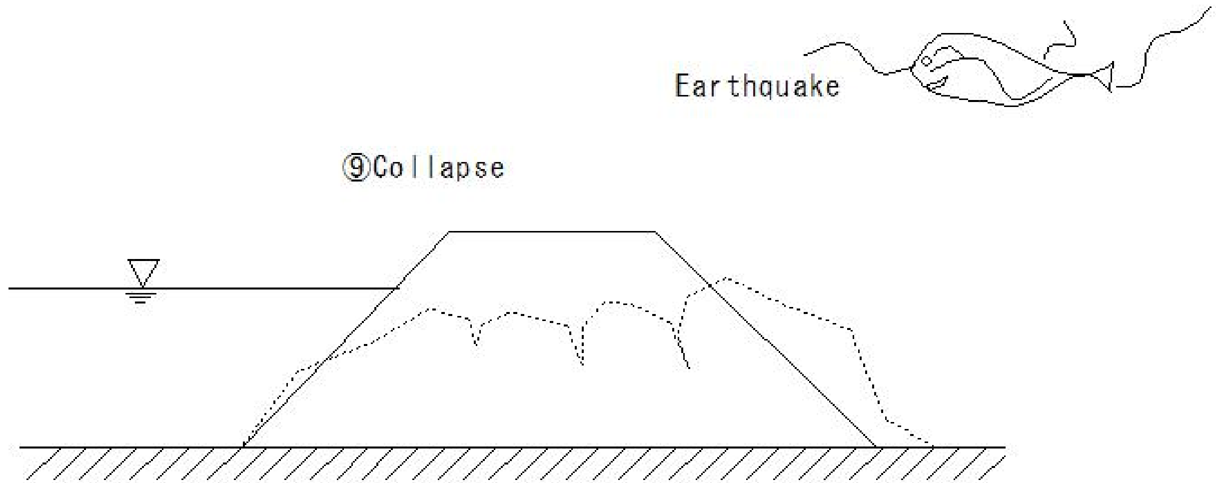
○ Damage type

⑨Collapse

○ Damage mechanism

a The embankment or ground may change significantly and collapse.

b It often leads to collapse, due to liquefaction of the embankment or foundation ground.



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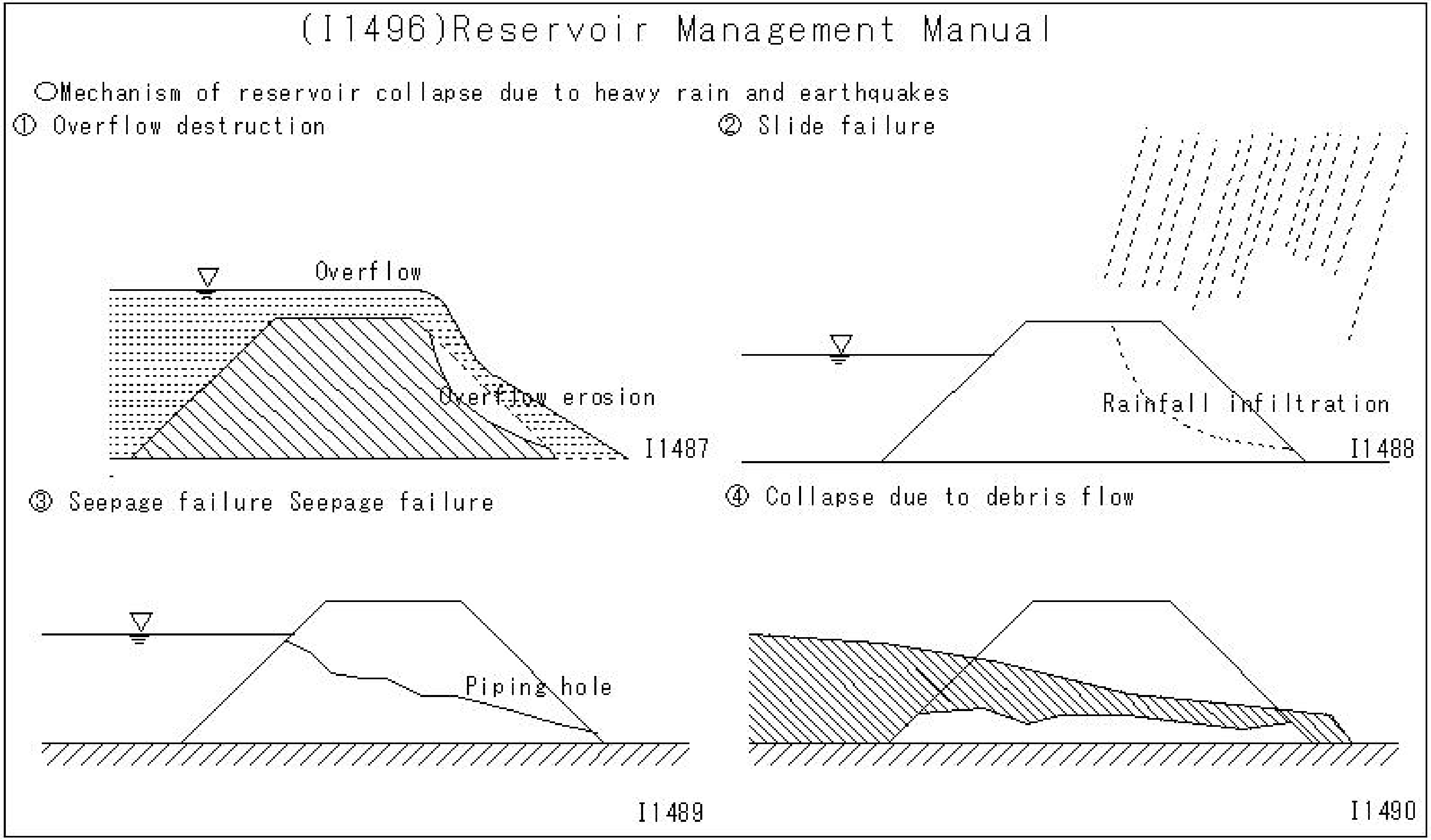

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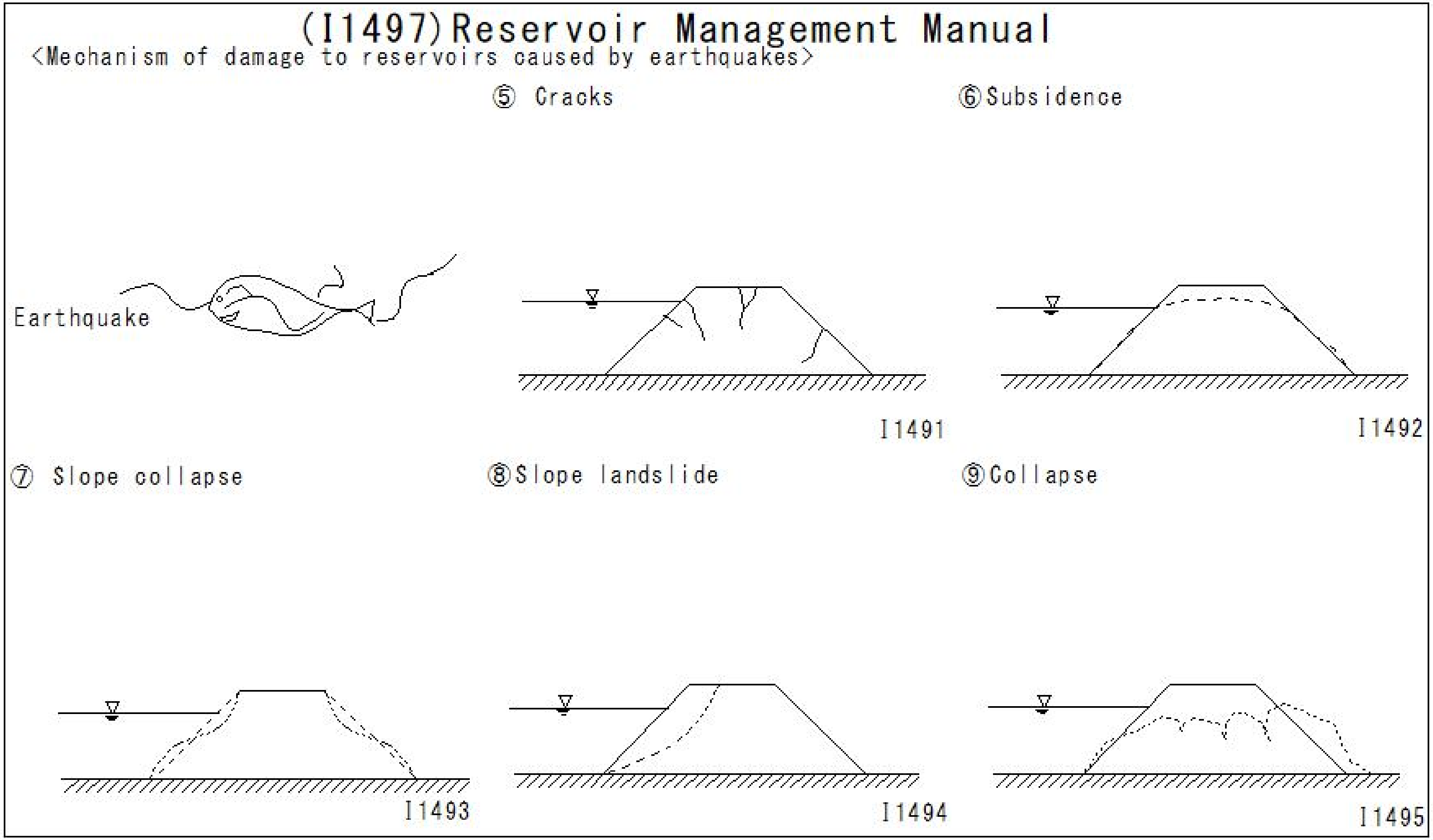

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(I1498)Reservoir Management Manual

Daily Management

Key Points

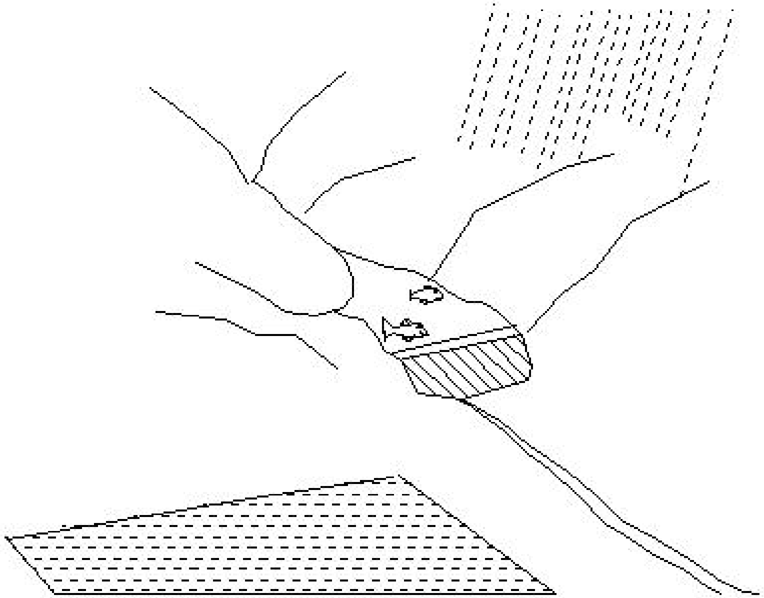
・Daily Management

① Detect any abnormalities in the facility early

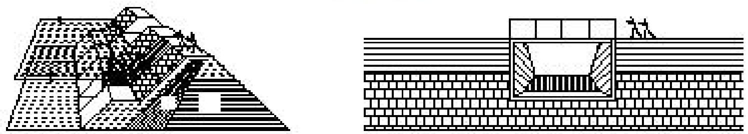
② Prevent dam collapses and natural disasters

③ To prevent unforeseen accidents

④ Work should always be done by at least two people, not by one person



at least two people



I1383

(I1499)Reservoir Management Manual

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Daily Management

Key Points

・Daily Management

○Upstream forest and development status

①In case of the forest upstream of the reservoir is cut down

②In case of fallen trees caused by typhoons are left unattended

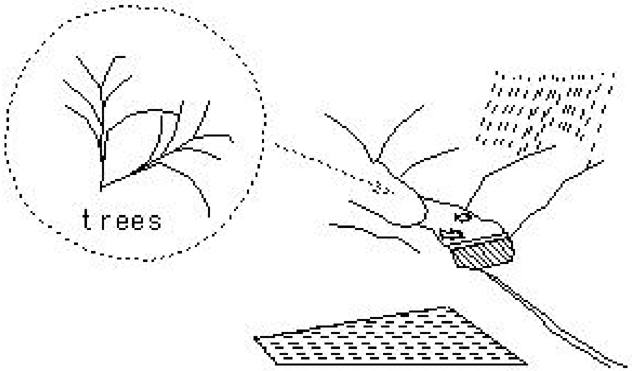
③The amount of water flowing into the reservoir may temporarily concentrate

④The amount of driftwood and garbage flowing in may increase

⑤Water may flow in beyond the drainage capacity of the spillway

⑥This may cause blockages caused by garbage, leading to the collapse of the embankment.

⑦Due to development of the surrounding area, such as residential development, the water level in the reservoir may rise faster than before during rainfall.



(I1500)Reservoir Management Manual

(I1500)Reservoir Management Manual

Daily Management

Key Points

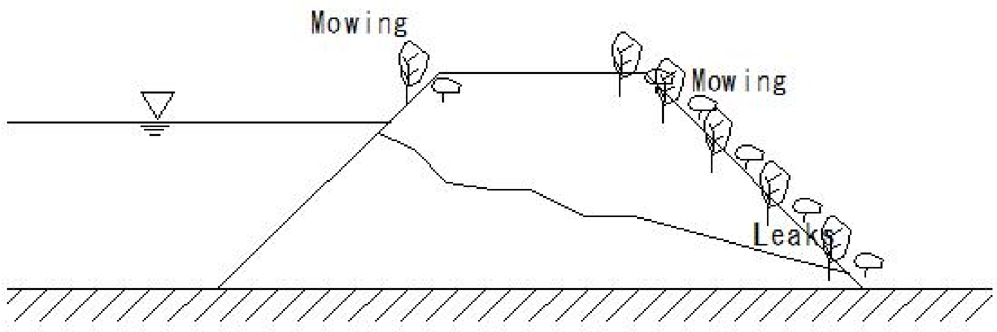
・Daily Management

○ Mowing and Inspection of the Embankment

① Mowing the embankment makes it easier to find irregularities such as overhanging slopes and leaks.

② Leaks are easier to find when the water level in the reservoir is high,

③ Mowing should be done with that time in mind, and the embankment should be inspected after mowing.



I1489

(I1501)Reservoir Management Manual

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Daily Management

Key Points

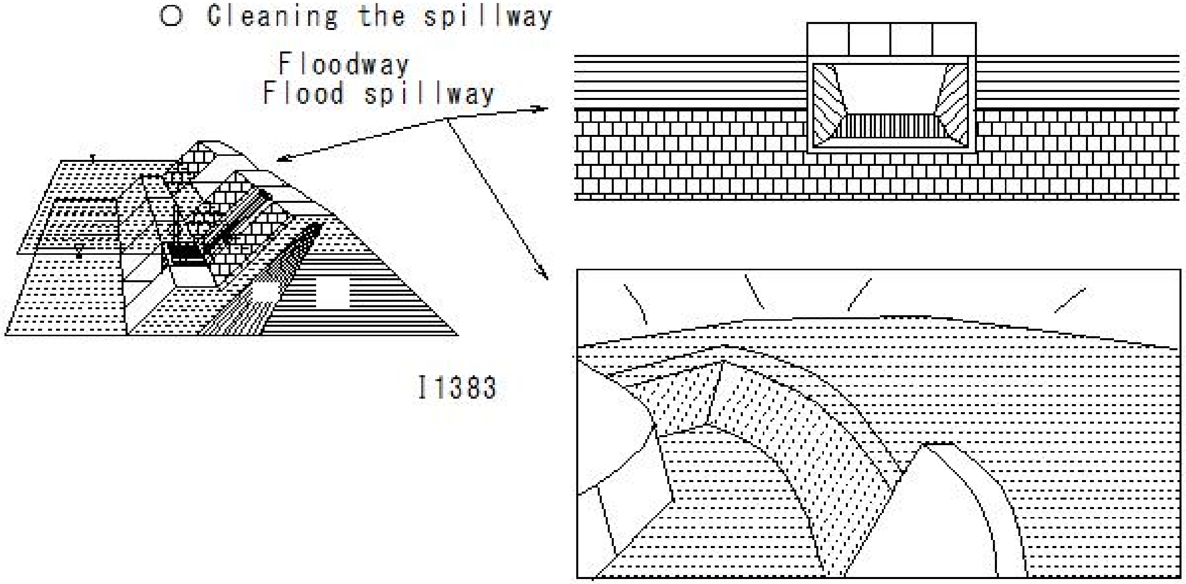
○ Cleaning the spillway

① In heavy rain, if water overflows from the embankment, it may break.

② Diligently remove any soil or driftwood from the spillway.

③ Never install sandbags or blockades (dropping boards or other objects into the spillway to block water) to increase the amount of water stored.

○ Cleaning the spillway



I1480

(I1502)Reservoir Management Manual

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Daily Management

Key Points

○Water Storage and Intake

①In case of the reservoir water level is suddenly raised or lowered

②Water seeping into the reservoir may cause the reservoir to break or the slope to slide.

③In case of water has been drained for a long period of time, do not fill the reservoir to capacity all at once

④Stock water gradually while checking for leaks,

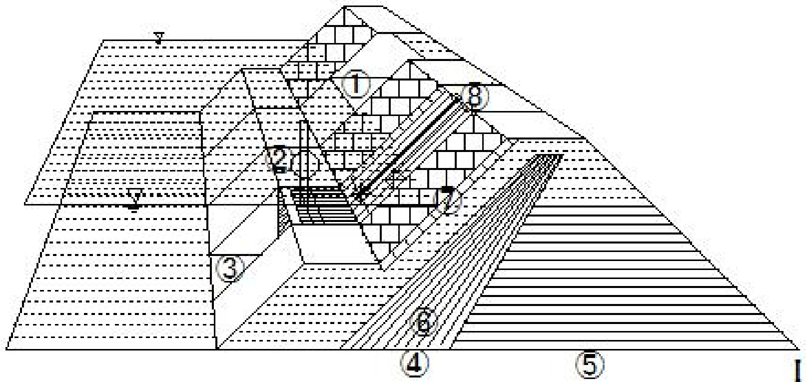
⑤On the other hand, when lowering the water level, except in the case of emergency discharge

⑥Open the inclined pipes from top to bottom, and lower the water level gradually.

⑦Regularly lubricate and clean the hoist, gate, inclined pipe covers, etc.

⑧In case of you notice any abnormality in the operation of the facility, inspect and repair it immediately.

① Flood spillway
② Water intake facility
③ Bottom gutter
④ Water-shielding section
⑤ Embankment
⑥ Core
⑦ Block pitching
⑧ Inclined gutter



I1382

(I1503)Reservoir Management Manual

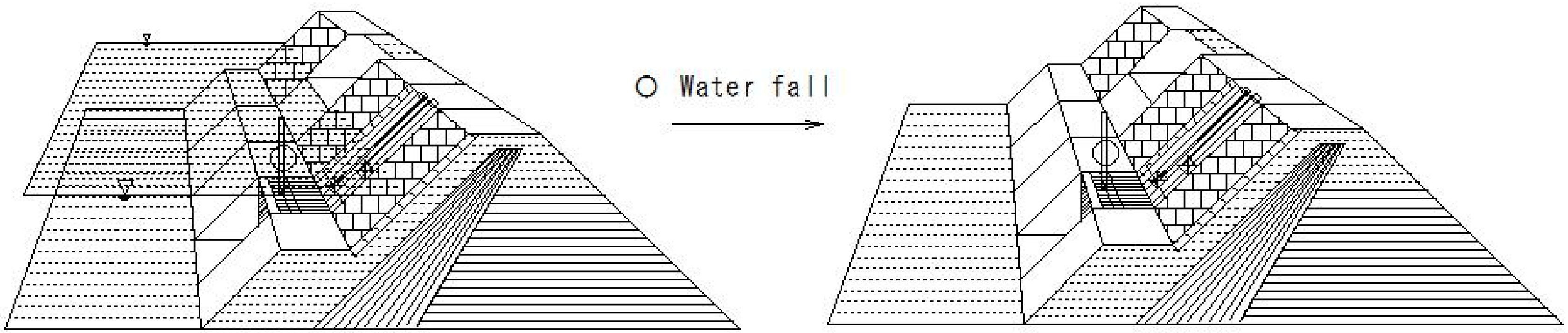
Daily maintenance

Key points

○ Water fall

① To inspect the spillway, diagonal gutters, bottom gutters, and stonework upstream of the embankment,

② Drain the water from the reservoir once after the irrigation season ends.



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(I1504)Reservoir Management Manual

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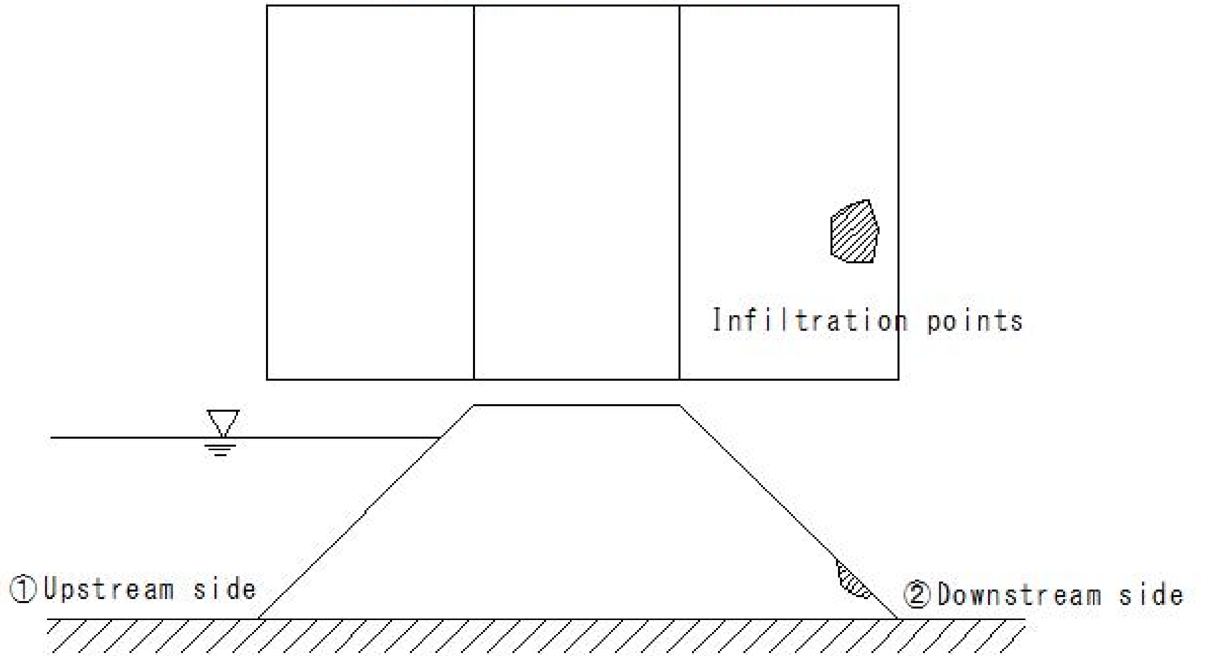
Daily management

Key points

○Embankment

①Perform regular inspections of the embankment to ensure that no deformations such as collapses, cracks, or bulges in the slope or leakage are overlooked.

Sketch of the affected area



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(I1505)Reservoir Management Manual

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Daily management

Key points

○Embankment

In particular, leakage can lead to the collapse of the reservoir, so it is important to pay attention to the following situations.

①Mudgy water mixed with soil is leaking (this is particularly dangerous).

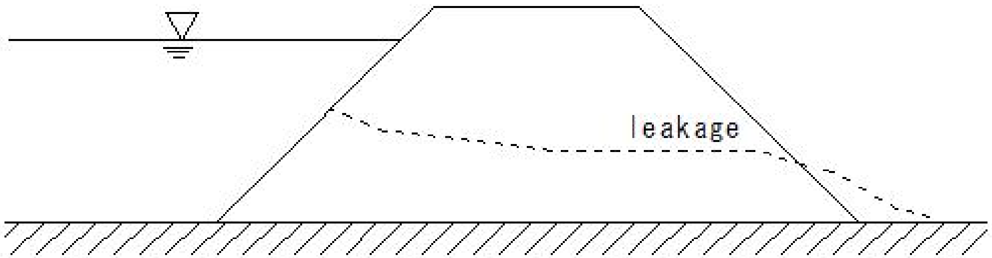
②The amount of leakage has increased, or the leakage point has moved to a higher position on the downstream slope of the embankment.

③There is a leaking hole on the downstream side of the reservoir embankment.

④It is becoming difficult for water to accumulate in the reservoir.

⑤Even during heavy rain, floodwaters do not overflow the spillway.

⑥Water is leaking from the bottom gutter even though no water is being taken in.



I1491

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Daily management

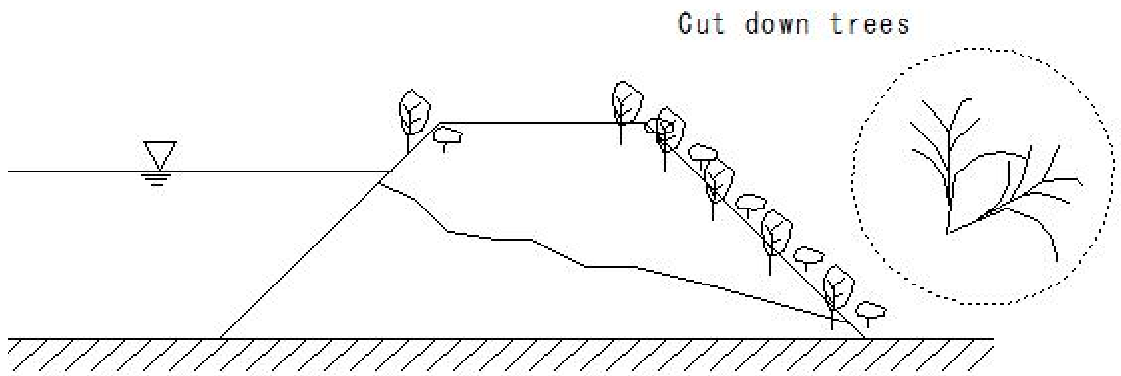
Key points

○Embankment

○ Cut down trees on the embankment slope and mow the grass regularly.

① Trees on the embankment slope can cause water leakage

② cut them down and uproot them.



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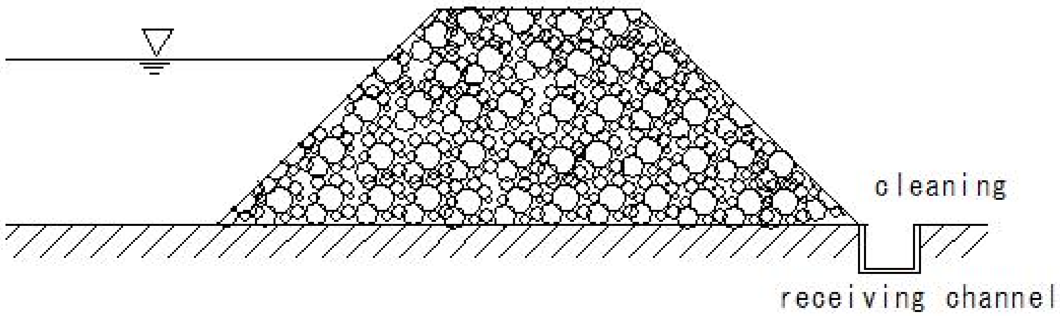
Daily Management

Key points

○Embankment

○Periodic cleaning of the receiving channel installed downstream of the embankment



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Daily Management

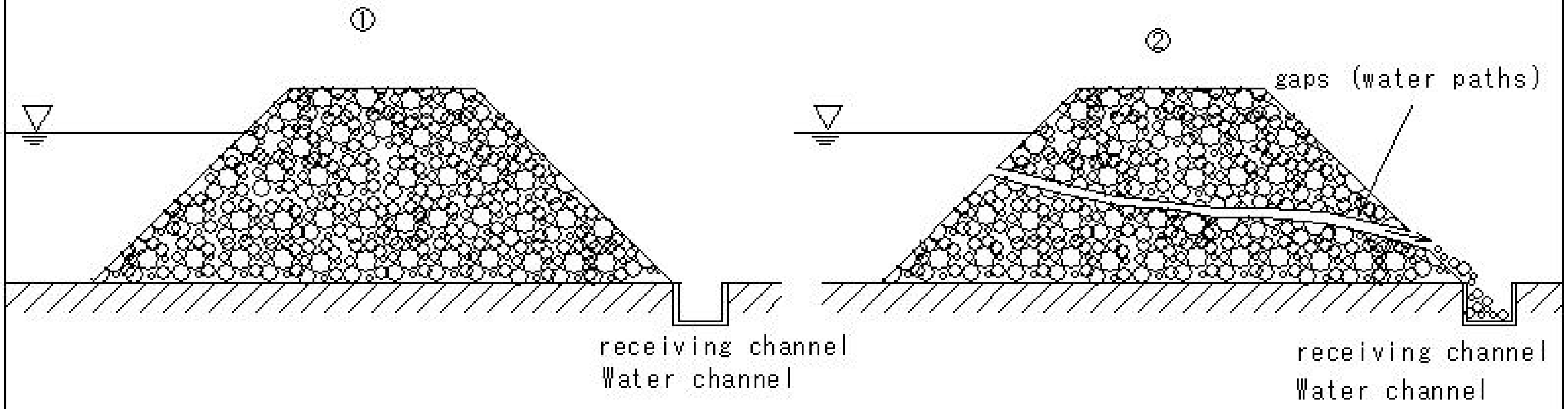
Key points

○Embankment

○Periodic cleaning of the receiving channel installed downstream of the embankment

① In a healthy embankment, the spaces between the soil particles are filled.

② In case of fine soil particles flow out of the embankment due to deterioration, gaps (water paths) are formed between the larger soil particles.



Imagine fine soil particles flowing out

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Daily Management

Key points

○ Embankment

・Identify areas that may be weak in the embankment and inspect them with special care

① High possibility of becoming weak

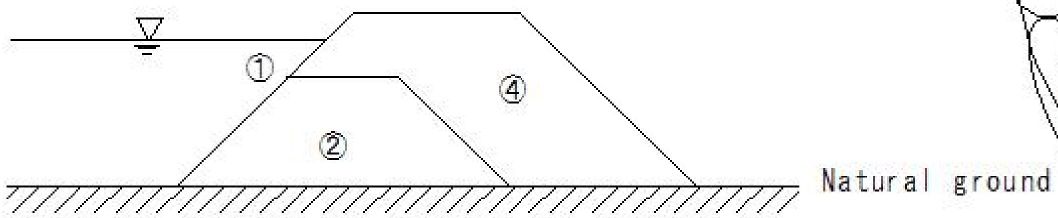
② Old embankment

③ Boundary between the new embankment and the old embankment that has been raised

④ New embankment (raised part)

⑤ Boundary between the ground and embankment

⑥ High possibility of becoming weak



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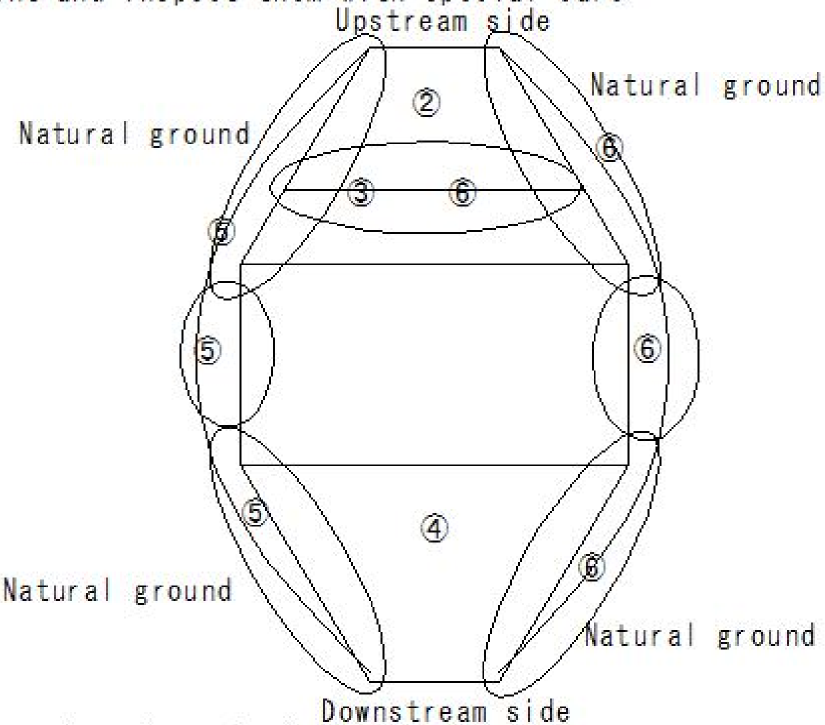
○ Cross-section



○ Plan view

Figure : Weak points for deterioration when the embankment is raised

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Daily Management

Key points

○Embankment

・Identify areas that may be weak in the embankment and inspect them with special care

①Boundary between renovated inclined and bottom sluices and new embankment

②Boundary between excavated and backfilled area during renovation (new embankment) and old embankment

③New embankment

④High possibility of becoming weak

⑤Old embankment

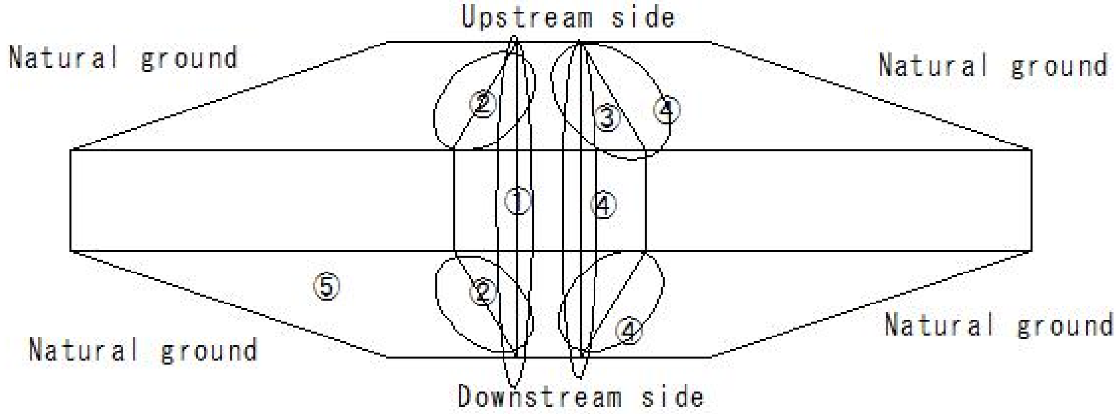

Figure Weak areas for deterioration when renovating inclined and bottom sluices

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Daily Management

Key points

○Embankment

○Stream water and water from the slope of the ground are eroding the embankment.

○Check the toe drain (masonry block, masonry block, etc.) for deformation and leakage

①The toe drain is used to quickly drain rainfall and stored water
that has infiltrated into the embankment,

②It is an important facility for lowering the water level that has infiltrated into the embankment
and maintaining the stability of the embankment

③In case of the embankment is in an unstable state, deformation may be observed in the toe drain,
so it is necessary to check it carefully

④Also, if the water leaking from the toe drain is mixed with soil and sand,
or if a large amount of water is seen from one part

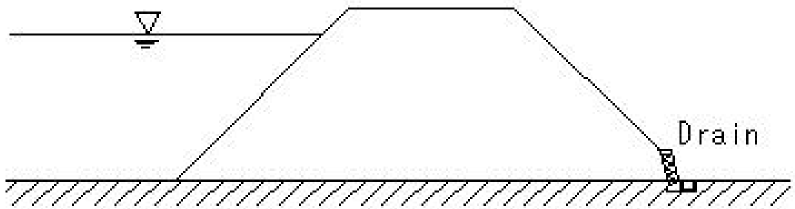

Figure Toe drain image I1491

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Daily Management

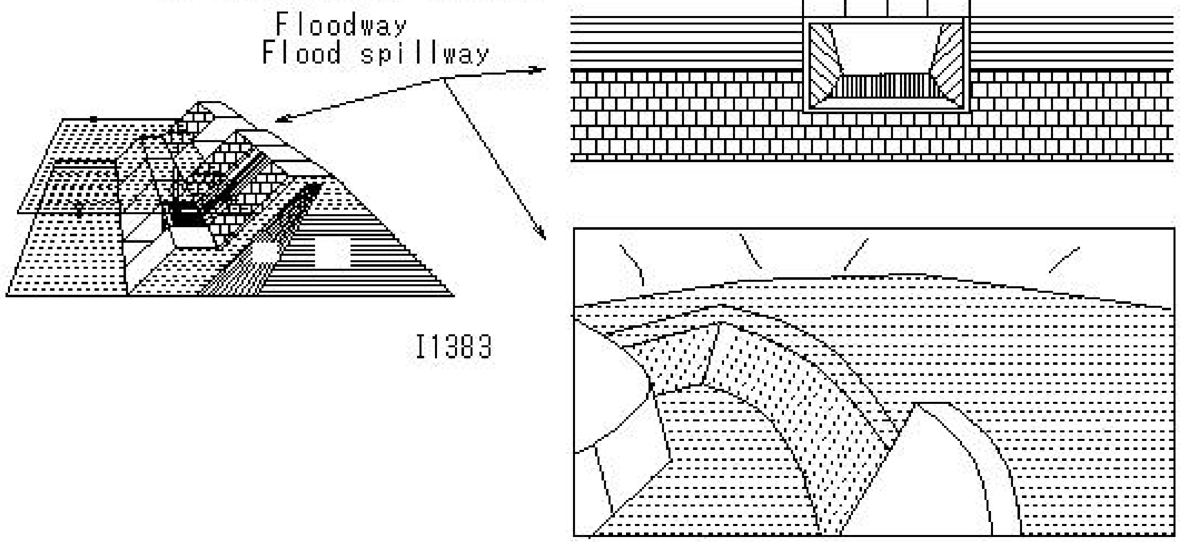
Key points

○Embankment

Spillway

①In case of there are any obstacles (driftwood, garbage, etc.) in the spillway overflow section or in the waterway downstream from the overflow weir, clean them up immediately.

○ Cleaning the spillway



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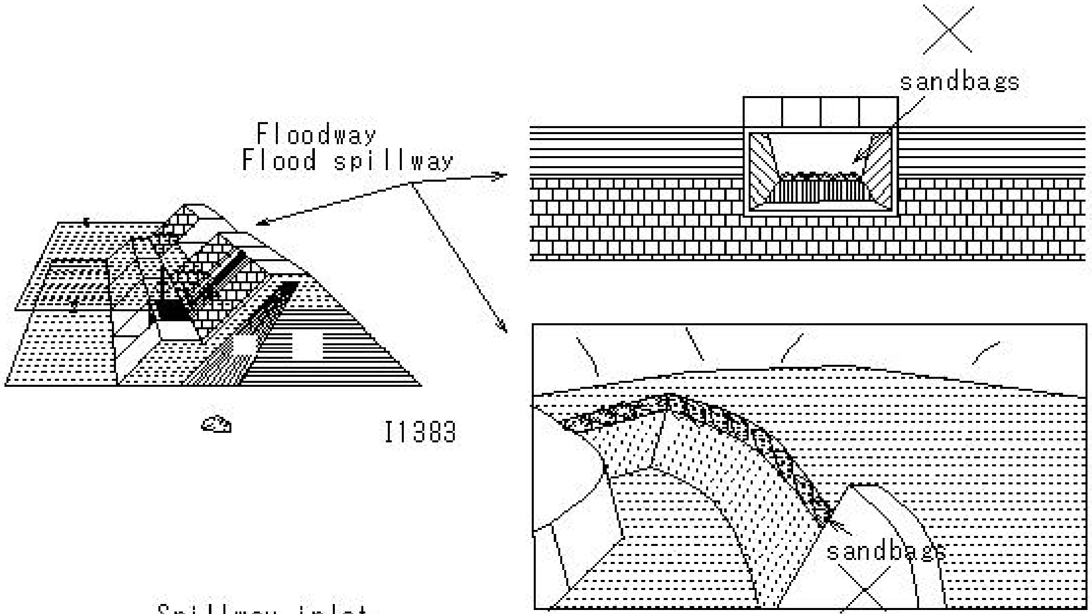
Daily Management

Key points

○Embankment

Spillway

Do not pile sandbags or install corner stoppers on the spillway inlet



Spillway inlet

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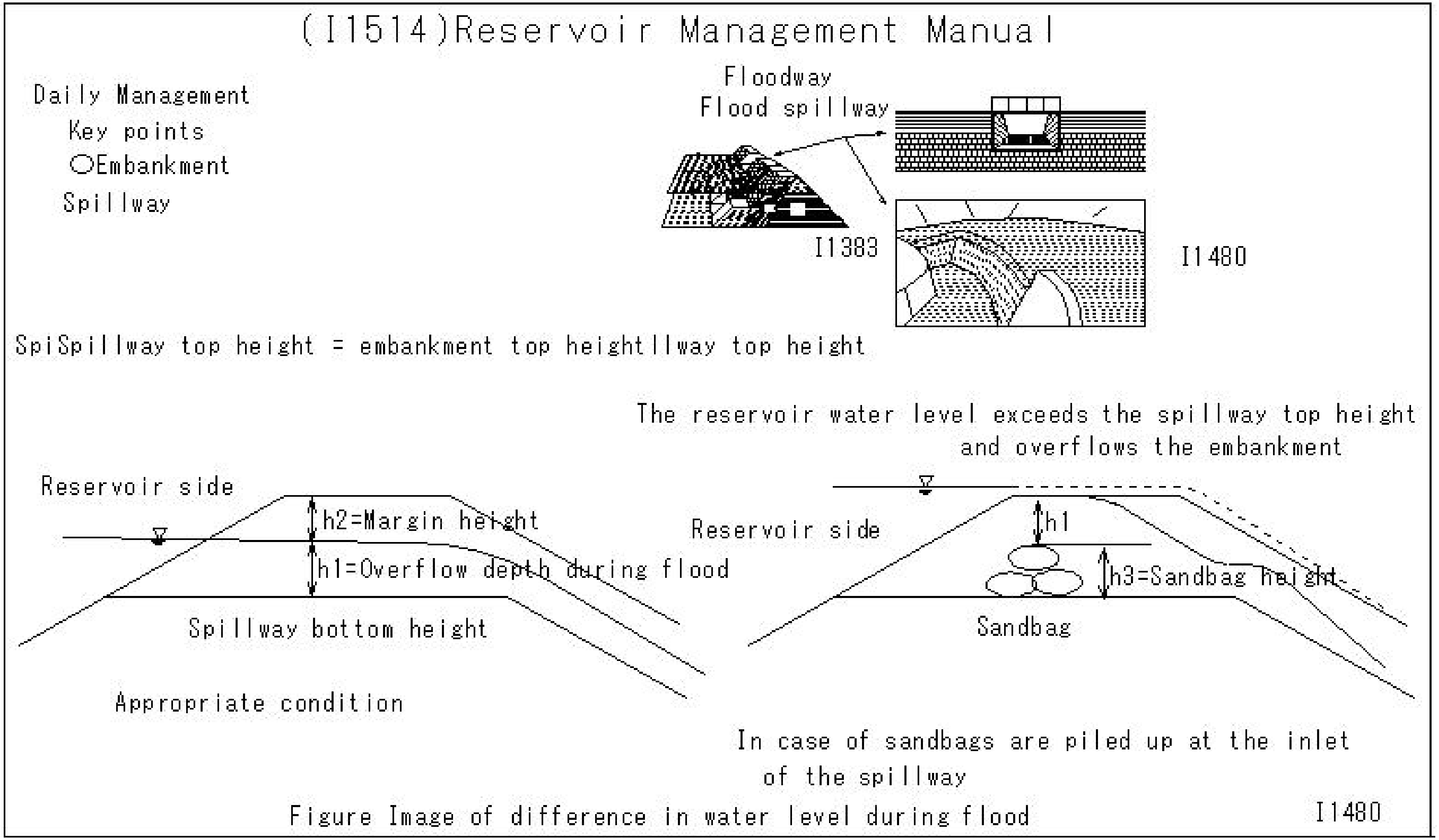

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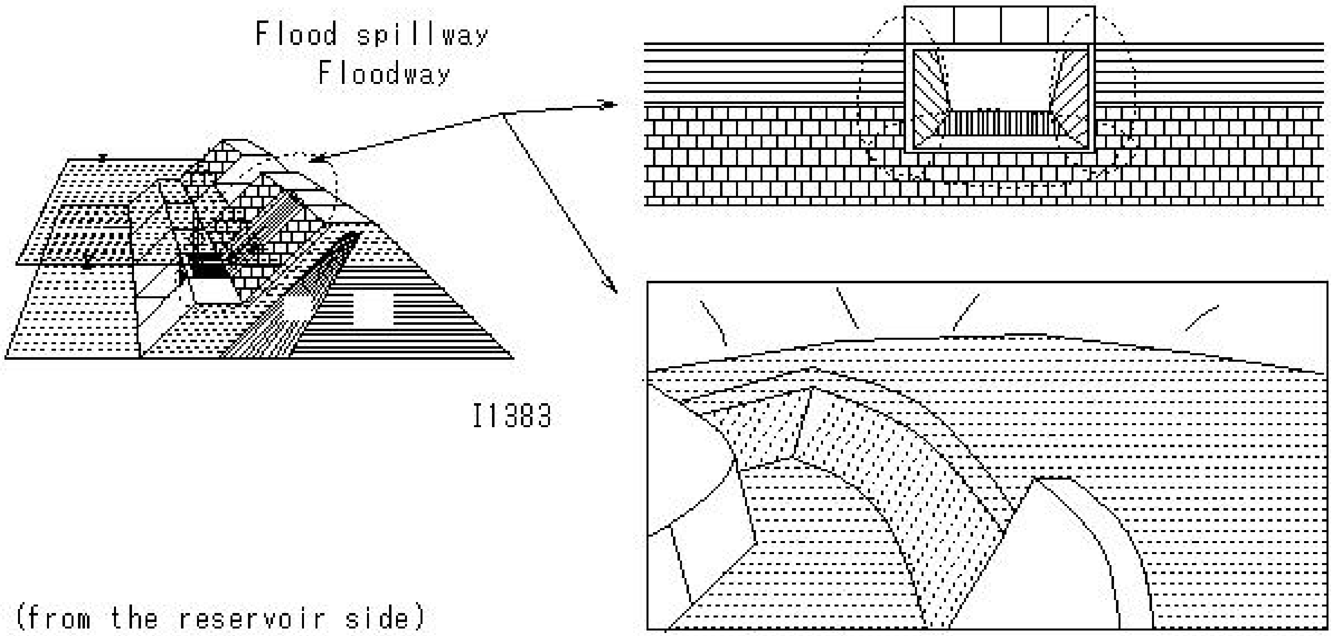
Daily Management

○Embankment Spillway

Check when water falls to see if the area around the spillway on the upstream slope of the levee is eroded.

Even if it is covered with revetment blocks, it is important to check that soil behind the blocks is not being washed away through gaps in the blocks.



Spillway (from the reservoir side)

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Daily Management

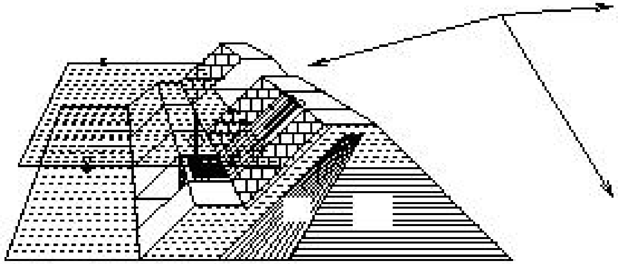
○Embankment　Spillway

Consider repairing or renovating the spillway in the following cases.

○ The spillway is made of earth.

○ The spillway is too small, so it is at risk of overflowing every time it rains.

○ Water overflowing from the waterway downstream of the spillway is eroding the embankment.



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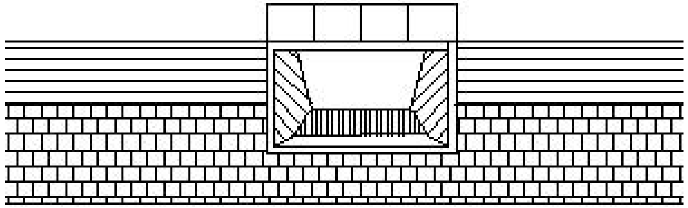

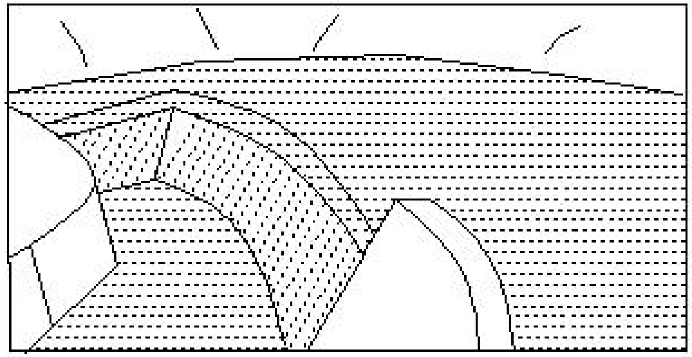

Spillway (from the reservoir side)

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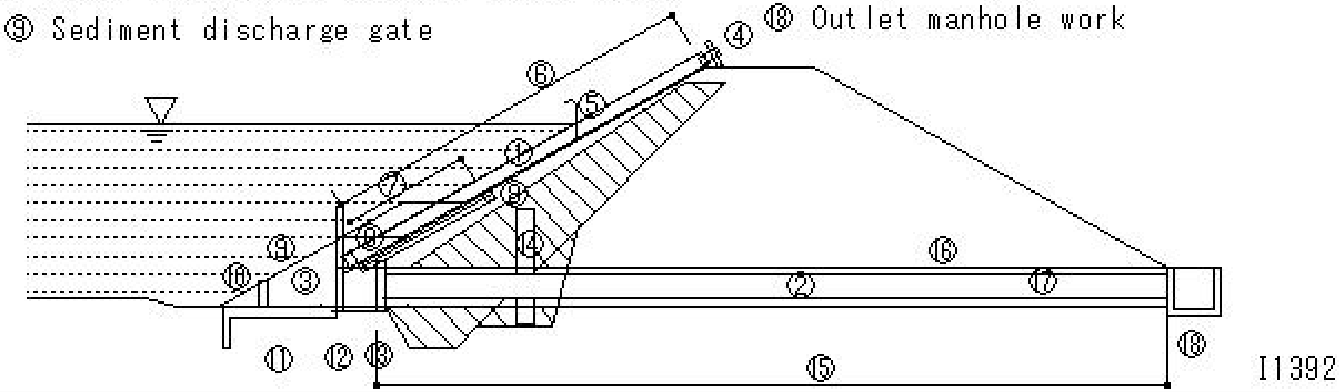
Daily Management

○Embankment

○Water Intake Facilities

①Regularly lubricate and clean the hoists, gates, diagonal drain covers, etc., and promptly inspect and repair any abnormalities in the operation of the facilities.

① Inclined gutter
② Bottom gutter
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gate
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work



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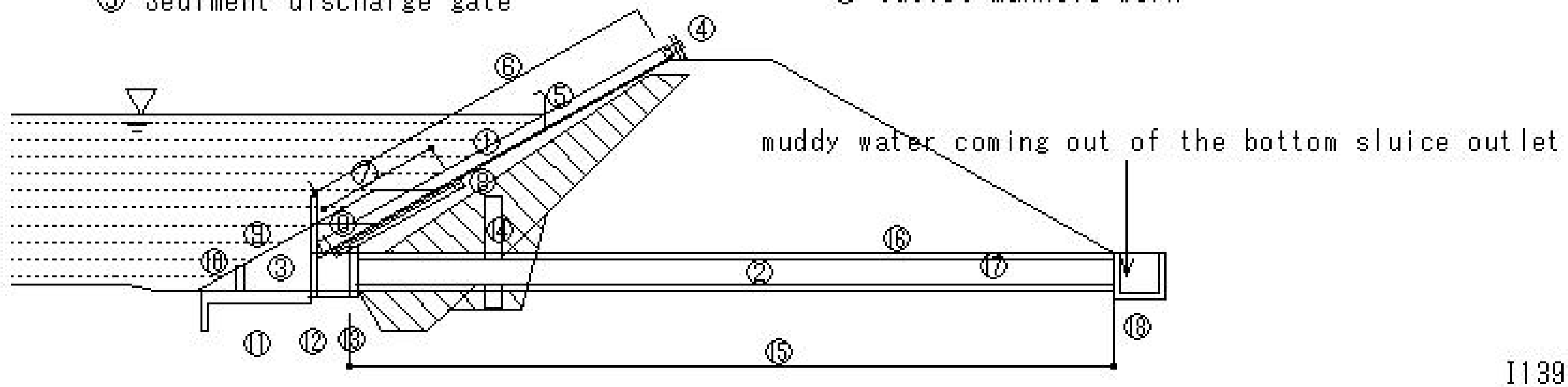
(I1518)Reservoir Management Manual

Daily Management

○Embankment Water Intake Facility

・Do not overlook the abnormality of muddy water coming out of the bottom sluice outlet even though the water intake gate is fully closed.

① Inclined gutter
② Bottom gutter
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gáte
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work



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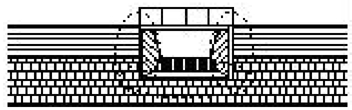
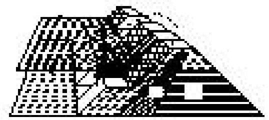
Daily Management

○Embankment Water Intake Facility

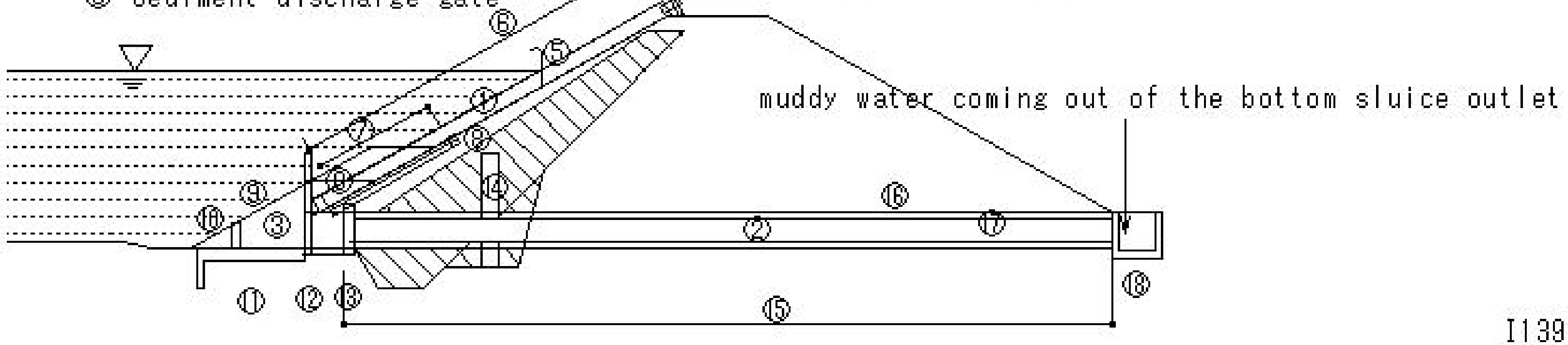


When water falls, check whether the area around the water intake facilities on the upstream slope of the embankment is eroded.

The boundary between the concrete and the embankment is eroded.



① Inclined gutter
② Bottom gutter
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gate
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work



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Daily Management

Safety Facilities

①Always check for any dangerous points in the reservoir you manage, in case of an emergency

②Check safety facilities such as fences on a daily basis, and repair any damaged ones promptly.
Also, install safety facilities if they are deemed dangerous

Damaged facility

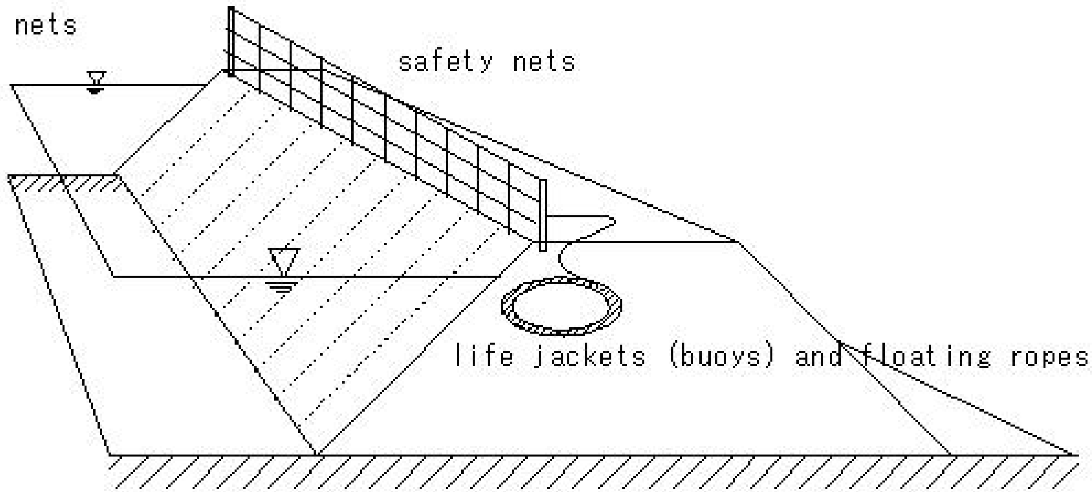
③If someone falls, they can grab onto the net immediately.

Installing safety fences

<Other examples of installing safety facilities>

Installing life jackets (buoys) and floating ropes

Installing safety nets



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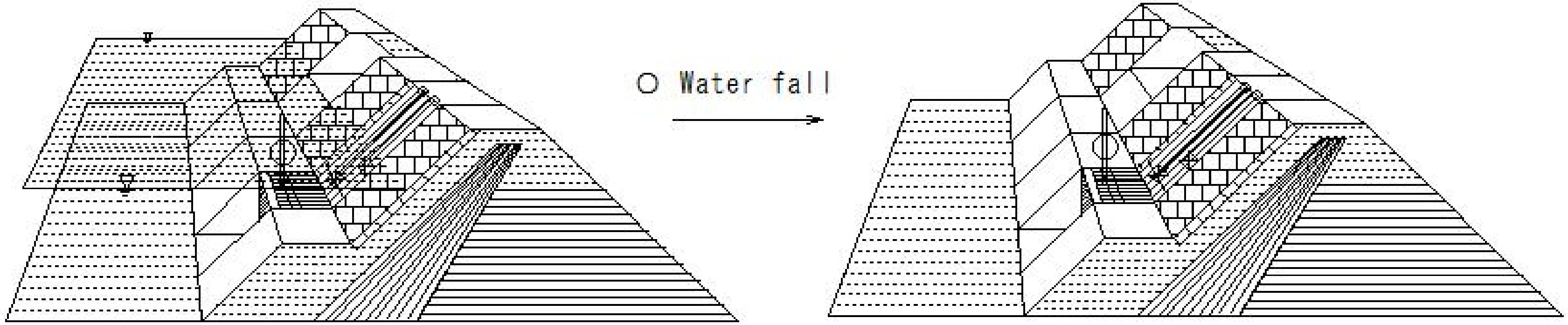
Daily Management

Pond draining (draining the water from a reservoir)

Pond draining (draining the water from a reservoir) improves water quality by removing the mud that has accumulated at the bottom of the pond, and also allows you to check areas that are normally invisible to the naked eye, such as erosion of the embankment and deterioration of the bottom gutter, which leads to proper maintenance.



I1503
I1382

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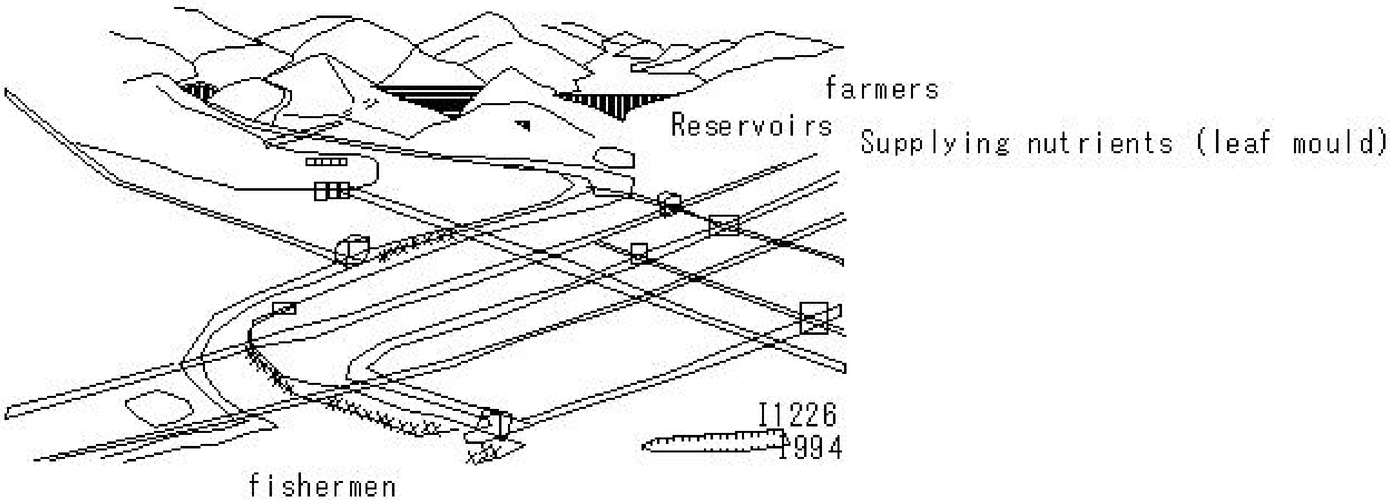
Daily Management

○ Collaborative activities between farmers and fishermen

1. Supplying nutrients (leaf mould) from the mountains that have accumulated in reservoirs to the sea
2. Collaborative activities between farmers and fishermen
3. In addition to removing mud, cooperation between farmers, fishermen and other local communities is promoted



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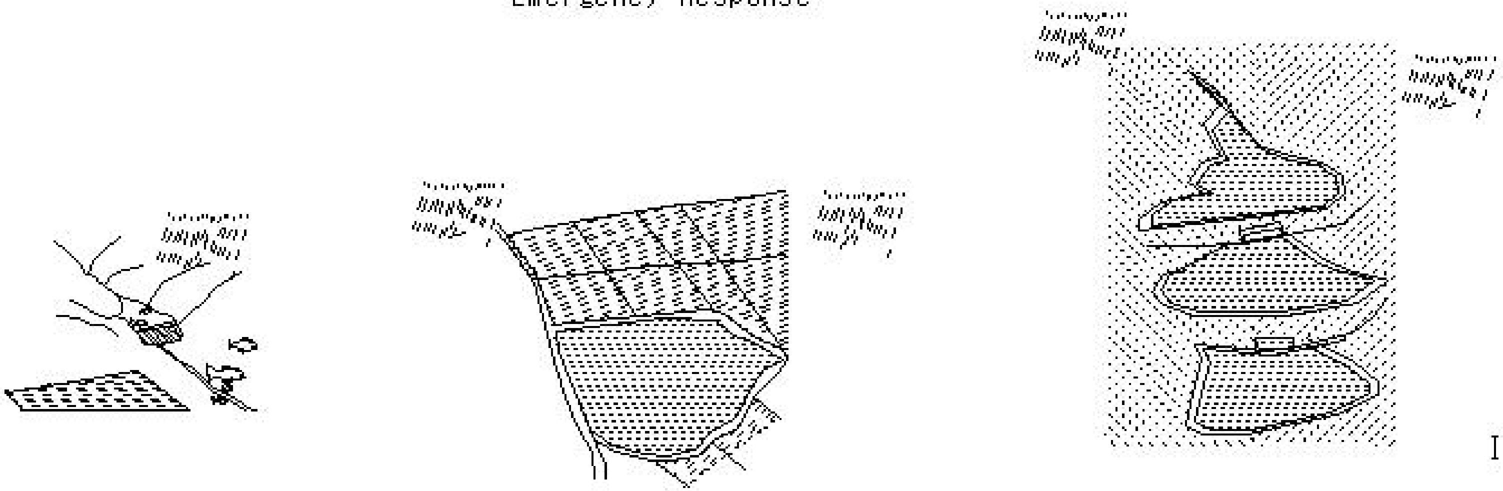
Daily Management

Emergency Response

① Prepare an information and communication system in case of disasters caused by heavy rain, earthquakes, etc.

② In case of traveling on-site, always travel with at least two people to ensure safety.

Emergency Response



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Daily Management

Emergency Response

(Flow of actions to take in case of heavy rain and flooding)

① Forecast of heavy rain and flooding

② Obtaining meteorological information (Methods: TV, radio, internet, etc.)

③ Issuing warnings (heavy rain special warnings)

○ Disaster prevention system

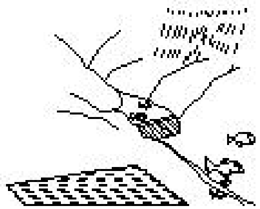
・ Coordination with related organizations

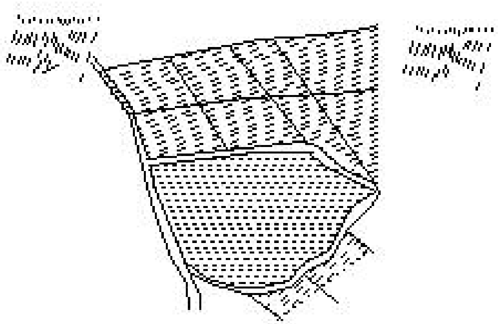
・ Monitoring and emergency inspection of reservoirs

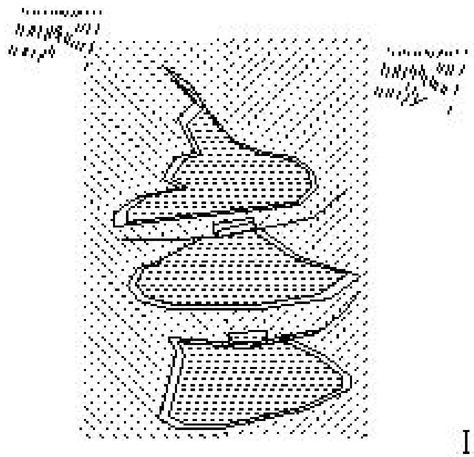
・ First aid measures

・ Continuous monitoring

Emergency Response







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Daily Management

Emergency Response

Key points when preparing for disaster prevention

・Promptly start preparations for disaster prevention, such as liaison and coordination and inspections

・Monitor the behavior of the reservoir (remote monitoring cameras, etc.)

・If you notice any abnormalities, contact the person in charge at the city or town immediately

Points to consider when determining whether a dam will burst

① Water level rises above the danger level

※This refers to the water level at which the reservoir may burst if the water level rises any higher, and is set in advance based on the design flood level and the normal full water level.

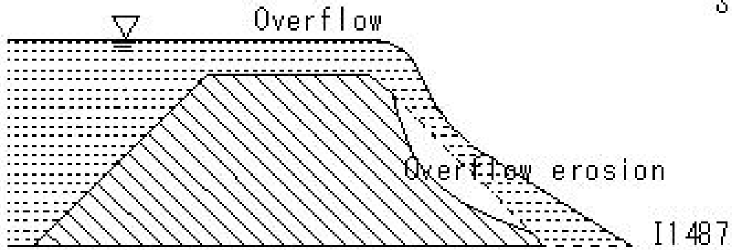
② Blockage of the spillway by driftwood, debris, etc.

③ Significant turbidity of the reservoir water (possibility of debris flow occurring upstream)

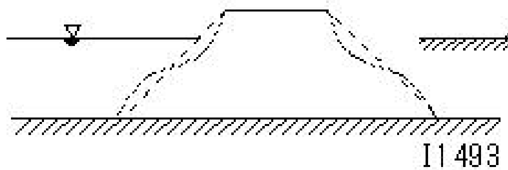
④ Increasing leakage (creation and expansion of cracks and water paths)

⑤ Increasing deformation such as increased overhang of the embankment slope

Overflow destruction



Slope collapse



Seepage failure Seepage failure

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Daily Management

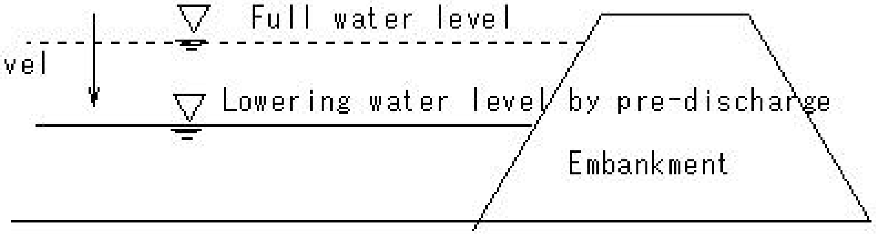
Emergency Response

○ Key points for responding to heavy rain, floods, and earthquakes

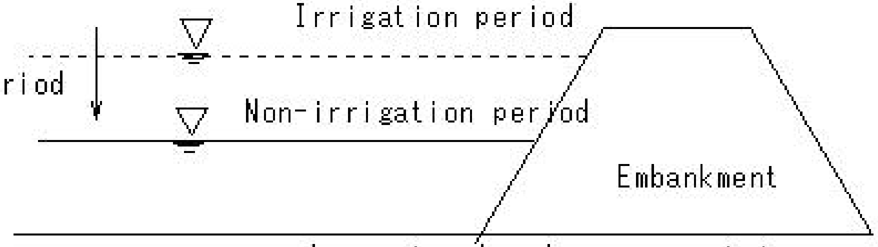
○ Implement pre-release and low water level management

① Lowering the water level by pre-release before rainfall secures free space in the reservoir (capacity to store incoming floodwaters)

② Not only does it secure free space, it is also expected to prevent the reservoir from bursting.



Pre-discharge image



Low water level management image

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Daily Management

Emergency Response

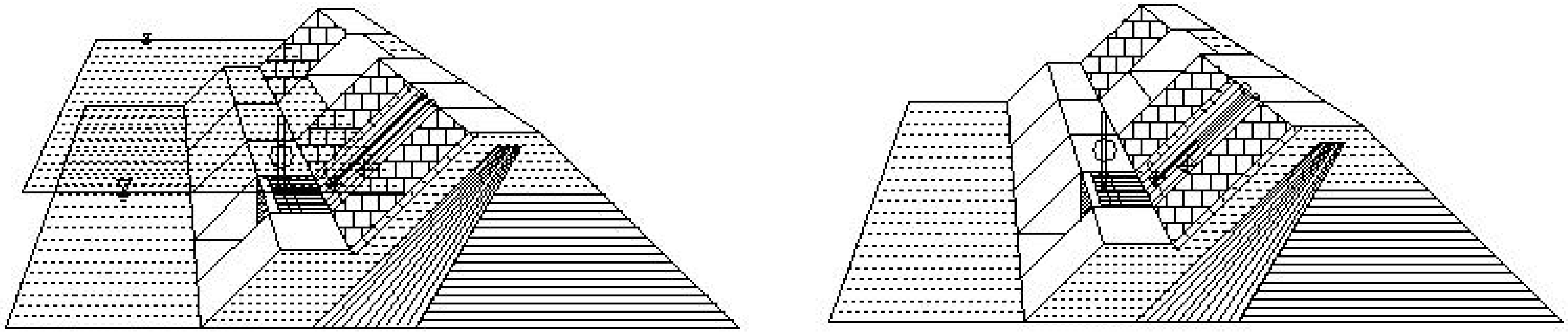
① Low water level management by pre-discharge before rainfall

This is a method of pre-discharging the water stored in the reservoir based on rainfall forecasts, etc., to ensure free capacity. Discharge

There are the following methods:

(a) Discharge by operating pre-discharge facilities (flood slits, reservoir plugs installed for discharge, discharge pipes, etc.)

(b) Discharge by operating water intake facilities



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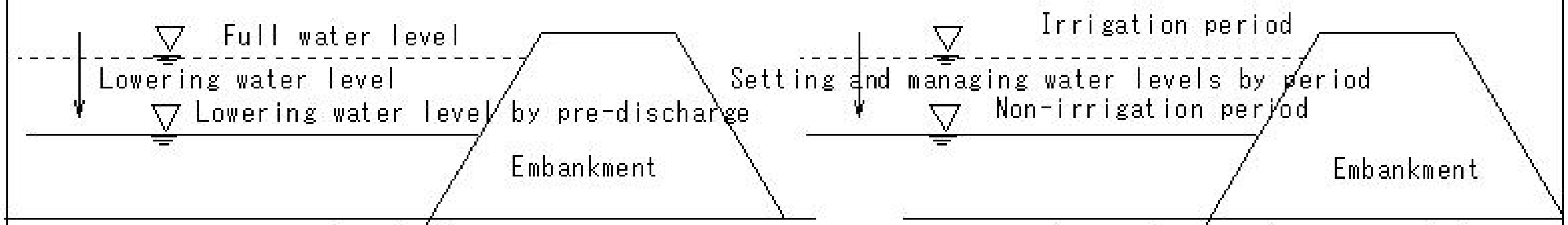
Daily Management

Emergency Response

② Low water level management by season This is a method of setting and managing water levels by season, rather than immediate management of lowering the water

(a) During non-irrigation seasons, water is completely drained or the water level is kept low at all times

(b) During irrigation seasons, water levels are set by season based on the amount of water required, ensuring free capacity.



Pre-discharge image　　Low water level management image

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Daily Management

Emergency Response

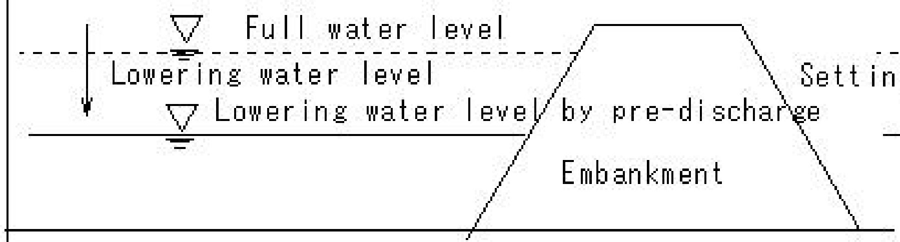
③ Points to note

① In case of the water level of a reservoir is suddenly raised or lowered, water may seep into the embankment, causing it to break or the slope to slide.

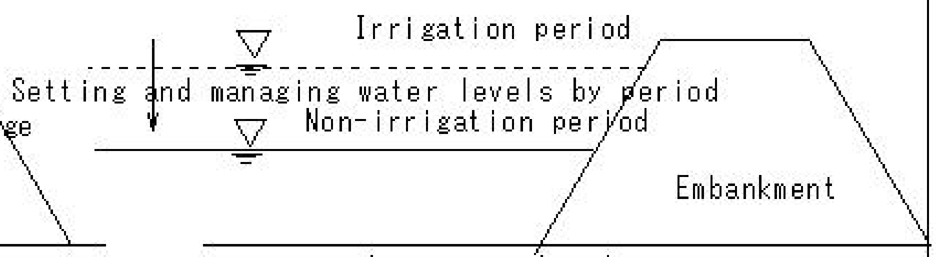
② In case of water has been drained for a long period of time, do not fill the reservoir to capacity all at once, but fill it gradually while checking for leaks,

③ When lowering the water level, except in the case of an emergency discharge,

④ lower it gradually, for example by opening the inclined gutters from the top down.



Pre-discharge image



Low water level management image

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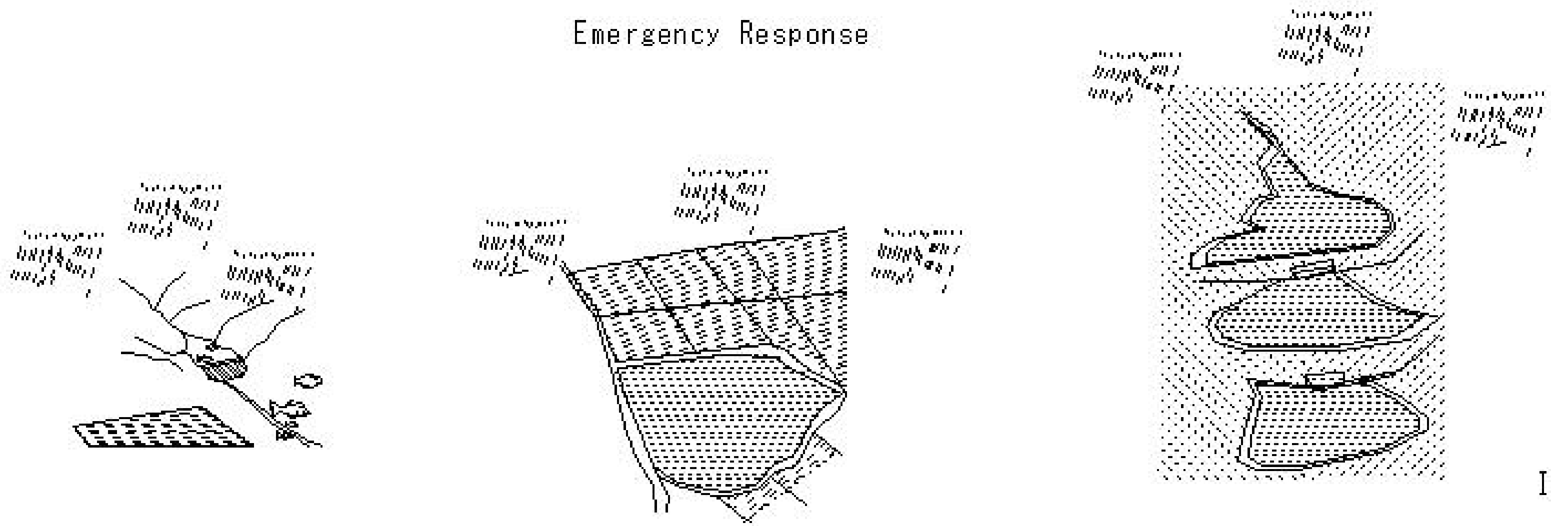
Daily Management

Emergency Response

During heavy rain and floods

1. In case of heavy rain or localized torrential rain is expected, monitor the reservoir carefully
2. In case of there is a risk of the water level reaching a dangerous level, immediately contact the city/town/village officials and the relevant communities.

Emergency Response



I1381

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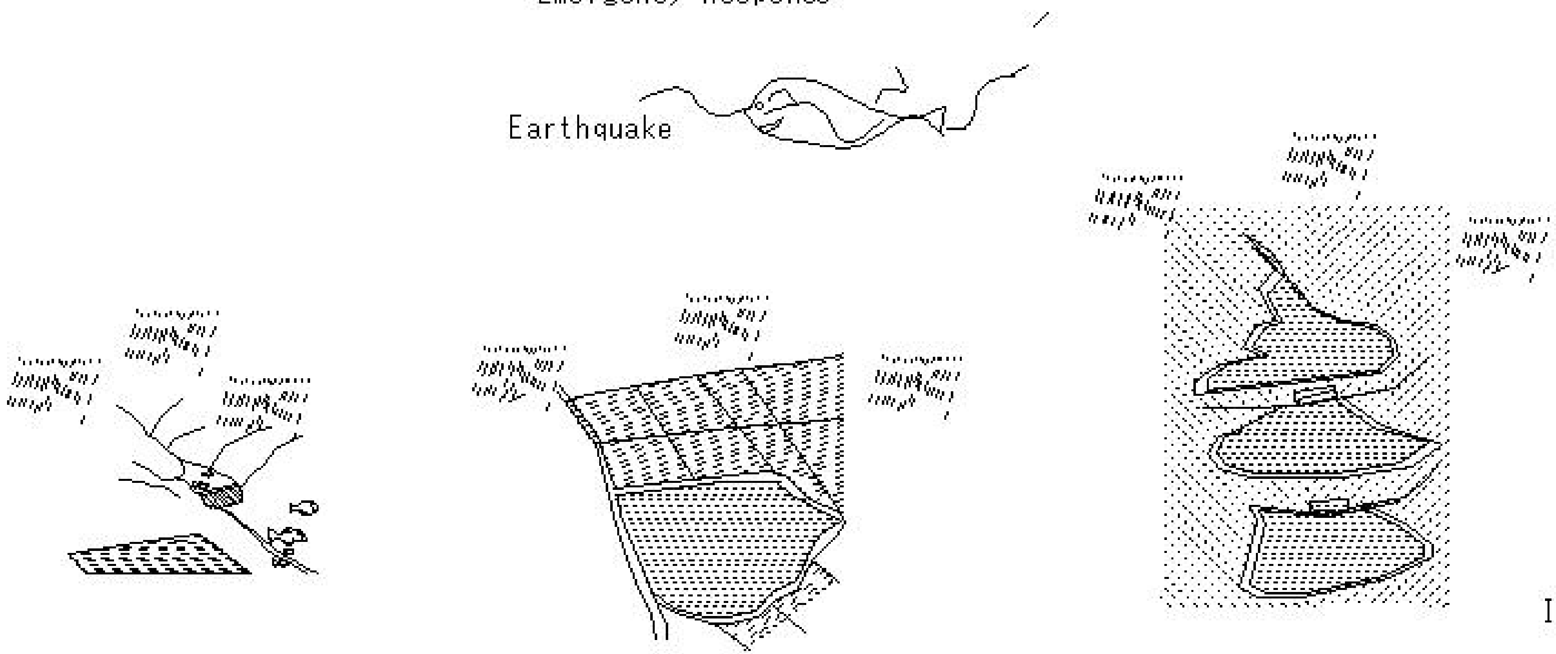
Daily Management

Emergency Response

During an earthquake (after an earthquake occurs)

1. In case of there is an earthquake with a seismic intensity of 4 or higher, inspect the reservoir while paying close attention to your own safety
2. Immediately report the inspection results to the municipal officials and relevant communities

Emergency Response



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Daily Management

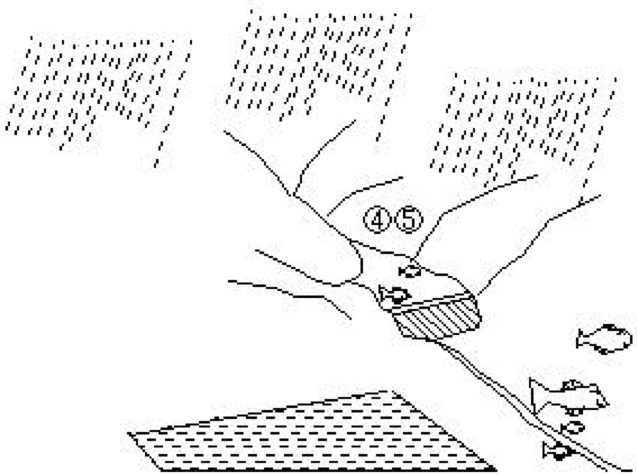
Emergency Response

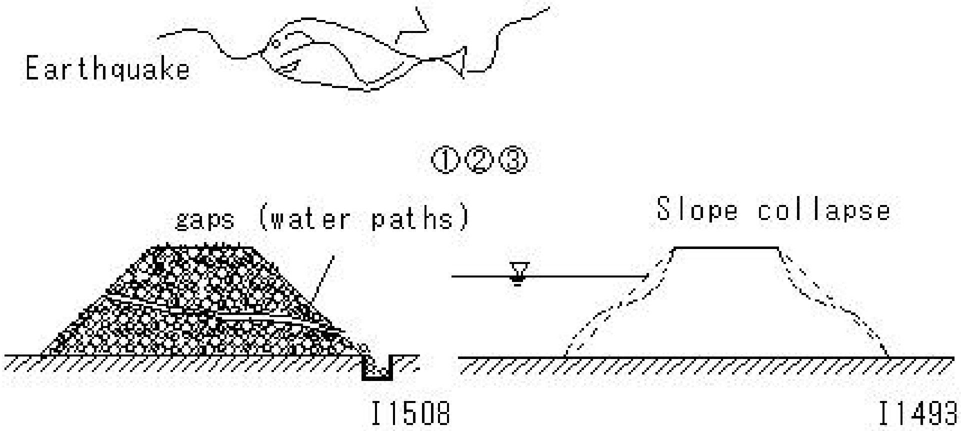
During an earthquake (after an earthquake occurs)

○Emergency inspection (within 24 hours, as soon as possible)

Carry out an emergency inspection and check for the following:

①The entire levee body (cracks, collapses, steps, etc.)
②The levee body and spillway (leaks, cracks, collapses, steps, etc.)
③Obstacles to the spillway
④Steps and cracks in the surrounding ground
⑤Collapses and landslides in the ground in the catchment area, etc.





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Daily Management

Emergency Response

During an earthquake (after an earthquake occurs)

① In case of a breach is predicted based on monitoring or emergency inspections during heavy rain, flooding, or an earthquake,

② the manager will take all possible emergency measures to ensure the safety of downstream areas

a Emergency release

b Emergency measures

a Emergency release

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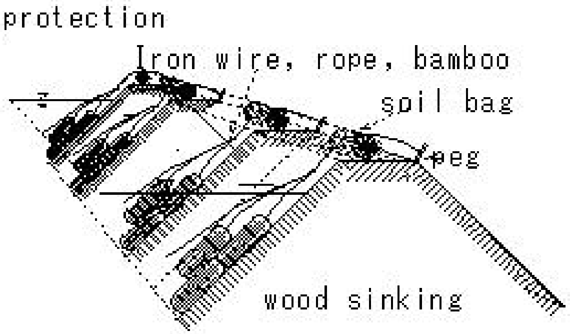
b Emergency measures



R340

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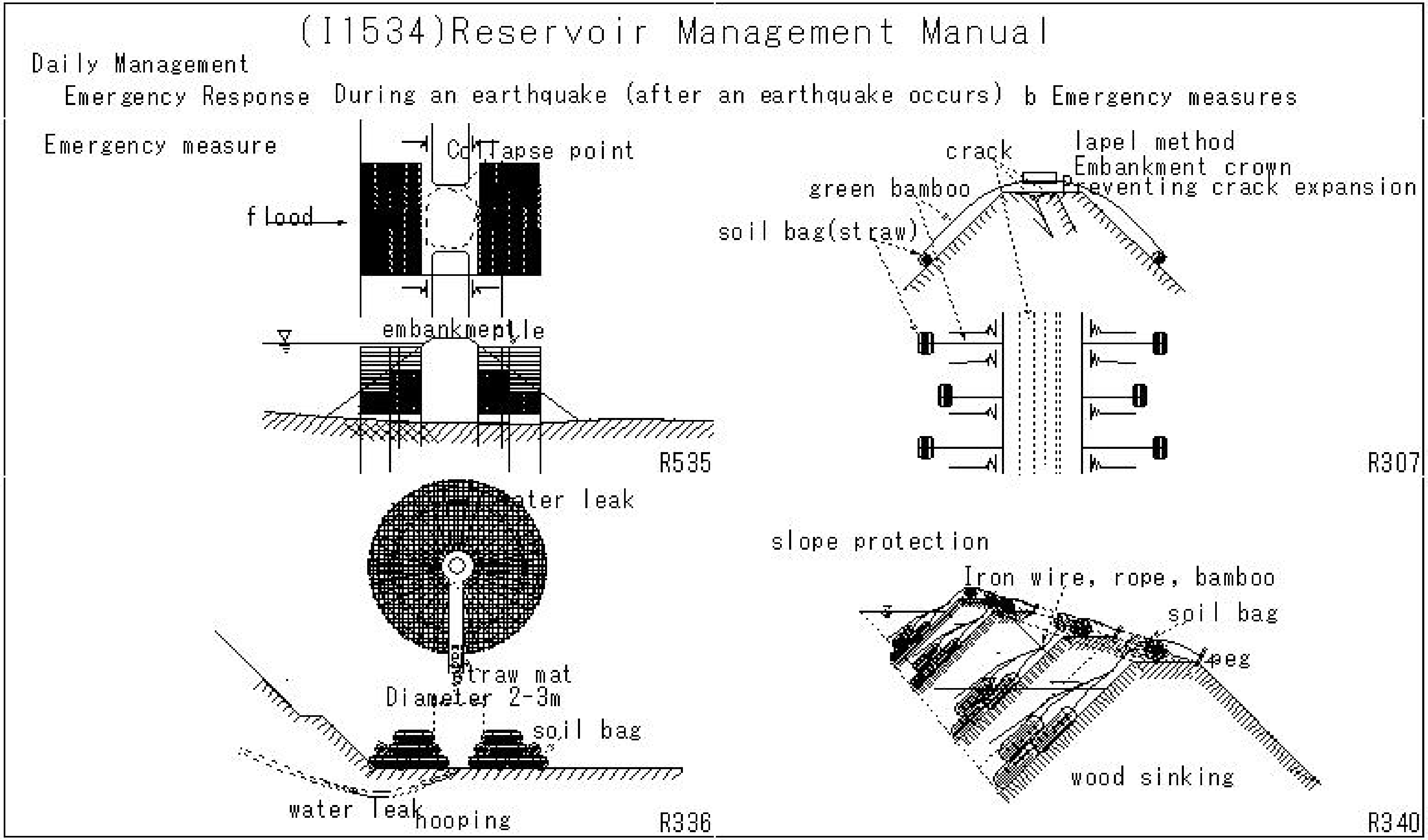

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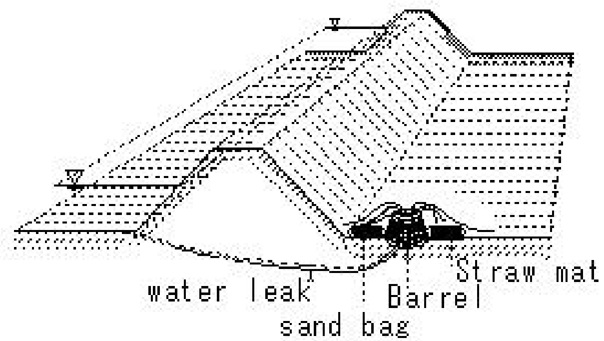
Daily Management

Emergency Response During an earthquake (after an earthquake occurs) b Emergency measures

prevent water leakage



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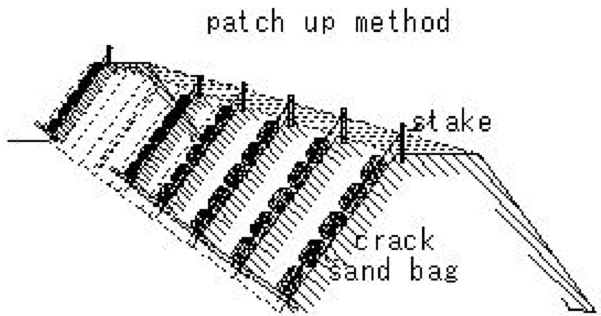
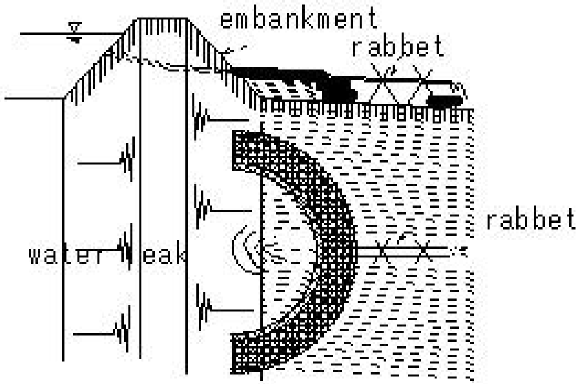
Bank protection(patch up method)



R421



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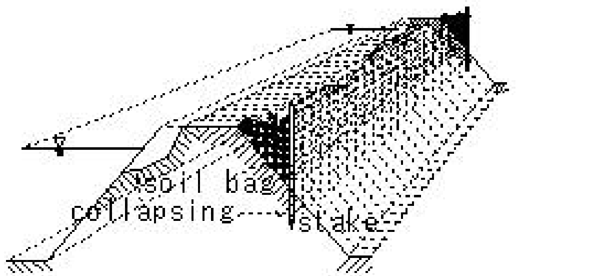

R423

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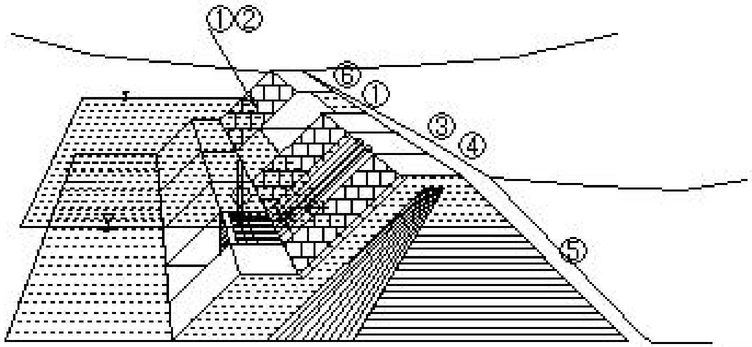
Daily Management

Inspection Checklist

・Organize specific points to check during daily inspection work
・Organize basic information before inspection, check repair history, etc.

Embankment

① There are areas where the embankment slope has collapsed, cracked, or bulged out.
② There are areas of damage or erosion in the riprap, stonework, and blocks on the embankment slope.
③ There are changes in vegetation on the downstream slope of the embankment, such as the overgrowth of ferns, butterbur, and moss, which prefer moist soil.
④ Spring water is seen from the edge of the embankment.
⑤ Seeping water, spring water, and sediment are seen on the downstream slope of the embankment and in the berm receiving channel.
⑥ Erosion of the embankment due to drainage from the connecting road is seen.



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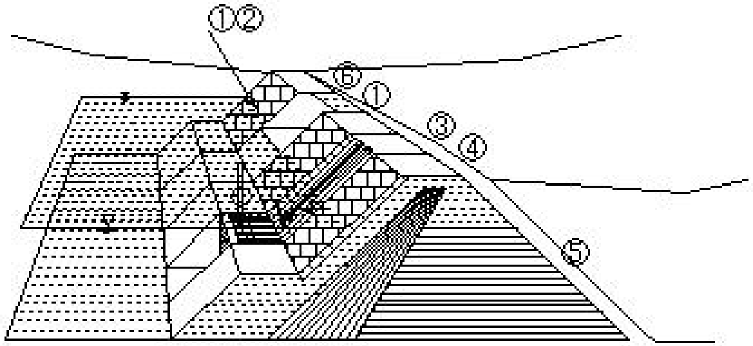
Daily Management

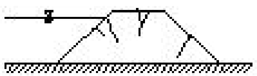
Inspection Checklist

Embankment

① There are areas where the embankment slope has collapsed, cracked, or bulged out.



Cracks



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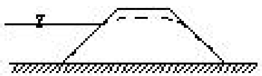
Subsidence



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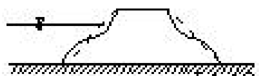
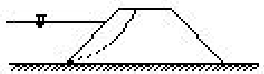
Slope collapse



I1493

Slope landslide



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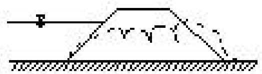
Collapse



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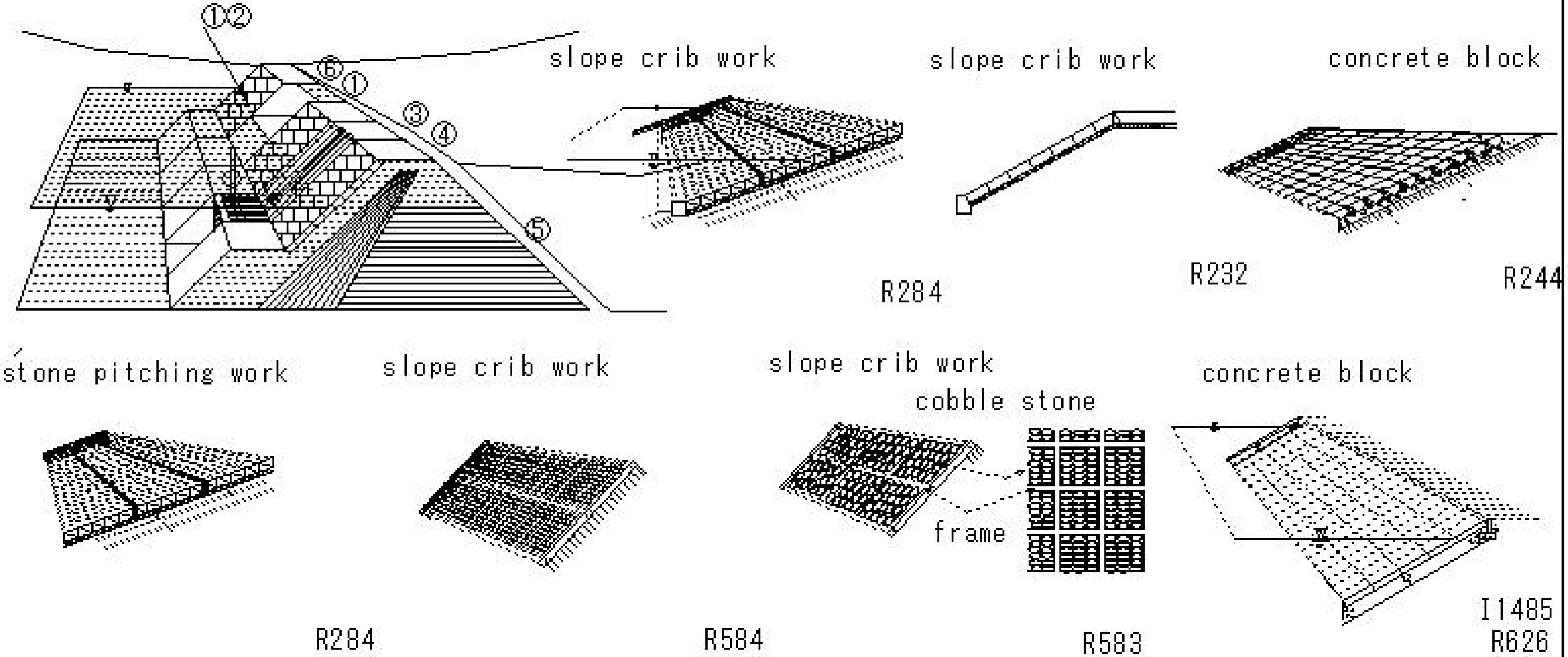
Daily Management

Inspection Checklist　Embankment

② There are areas of damage or erosion in the riprap material, stonework, and masonry blocks on the embankment slope.



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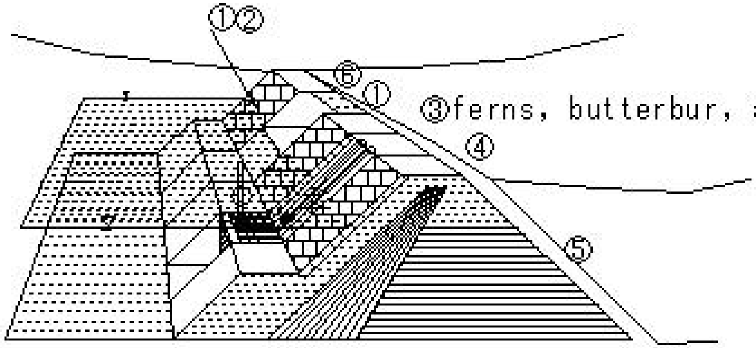
Daily Management

Inspection Checklist　Embankment

③ There are changes in vegetation on the downstream slope of the embankment, such as the overgrowth of ferns, butterbur, and moss, which prefer moist soil.



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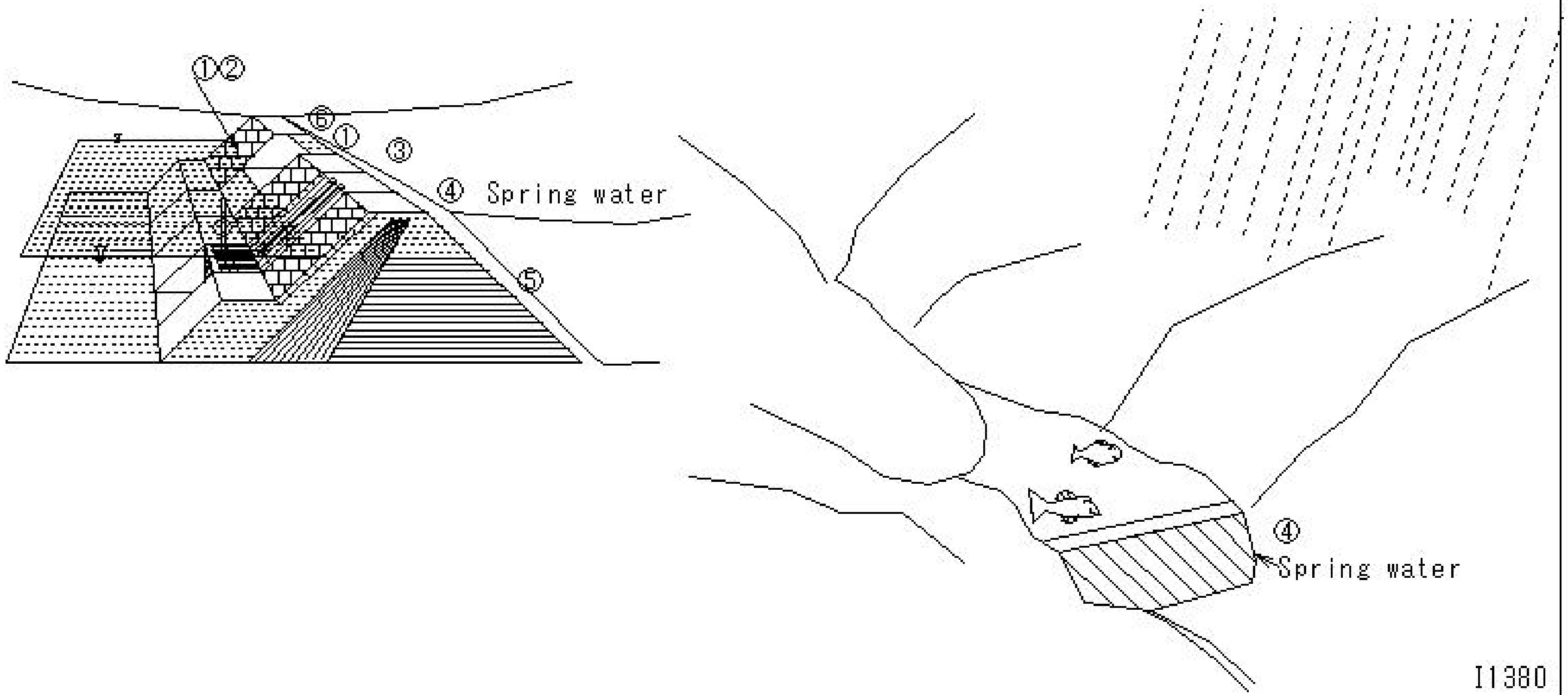
Daily Management

Inspection Checklist Embankment

④ Spring water is seen from the edge of the embankment.



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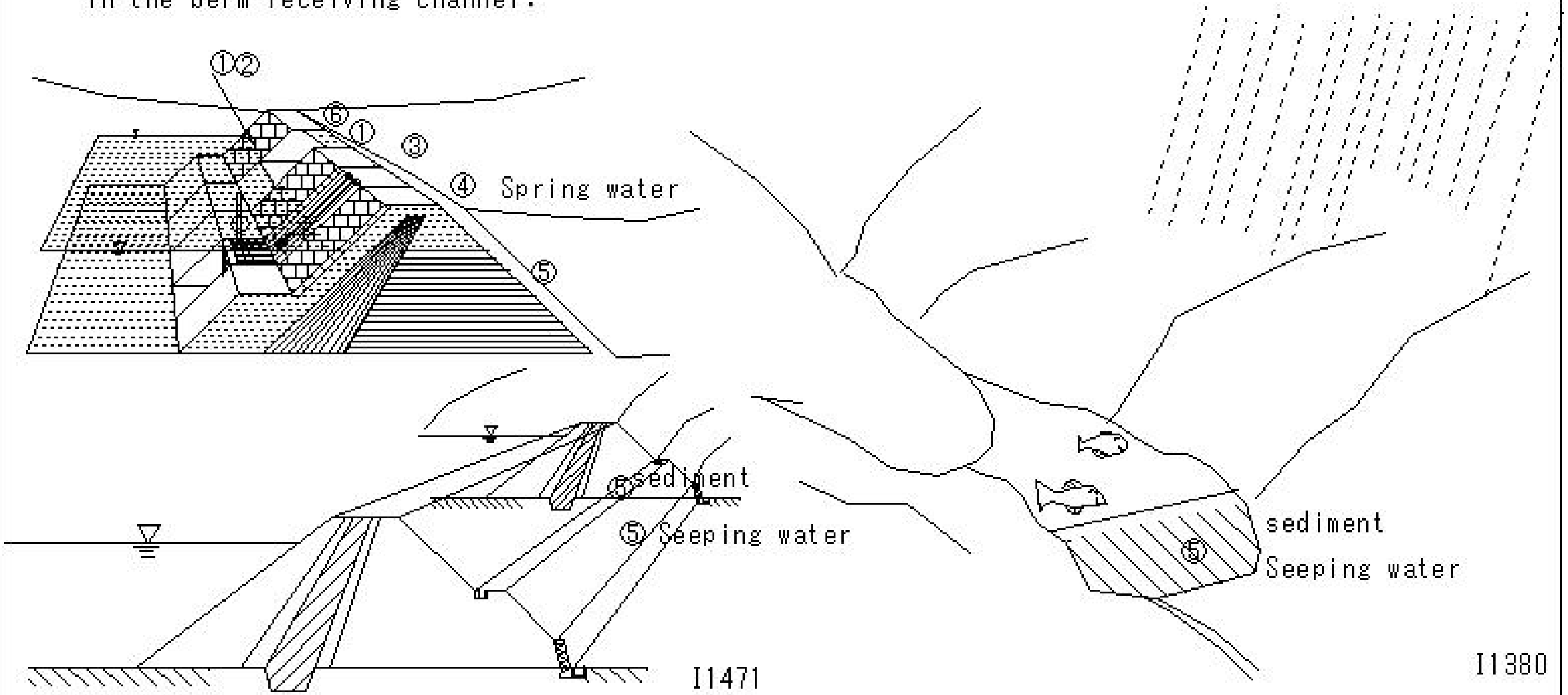
Daily Management

Inspection Checklist Embankment

⑤ Seeping water, spring water, and sediment are seen on the downstream slope of the embankment and in the berm receiving channel.



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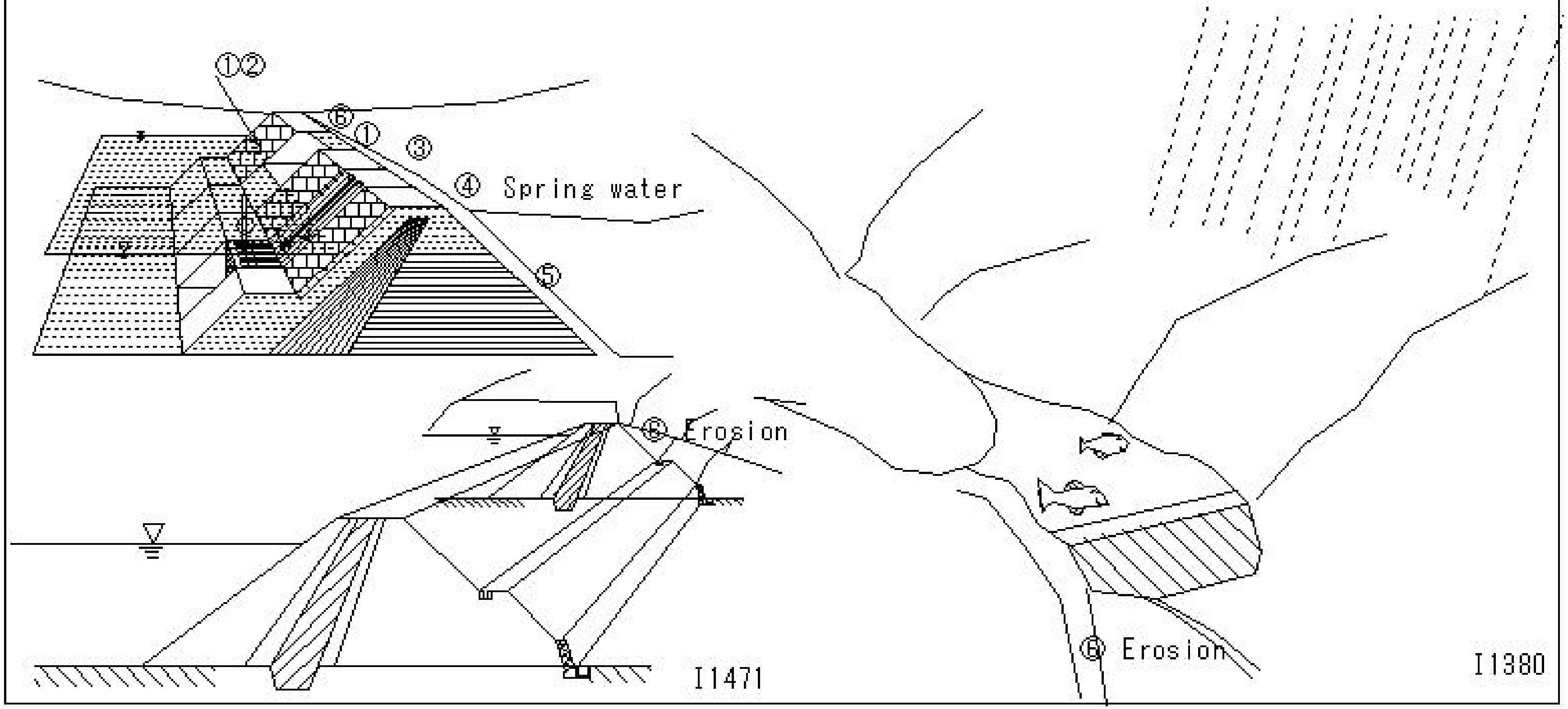
Daily Management

Inspection Checklist　Embankment

⑥ Erosion of the embankment due to drainage from the connecting road is seen.



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Daily Management

Inspection Checklist Spillway

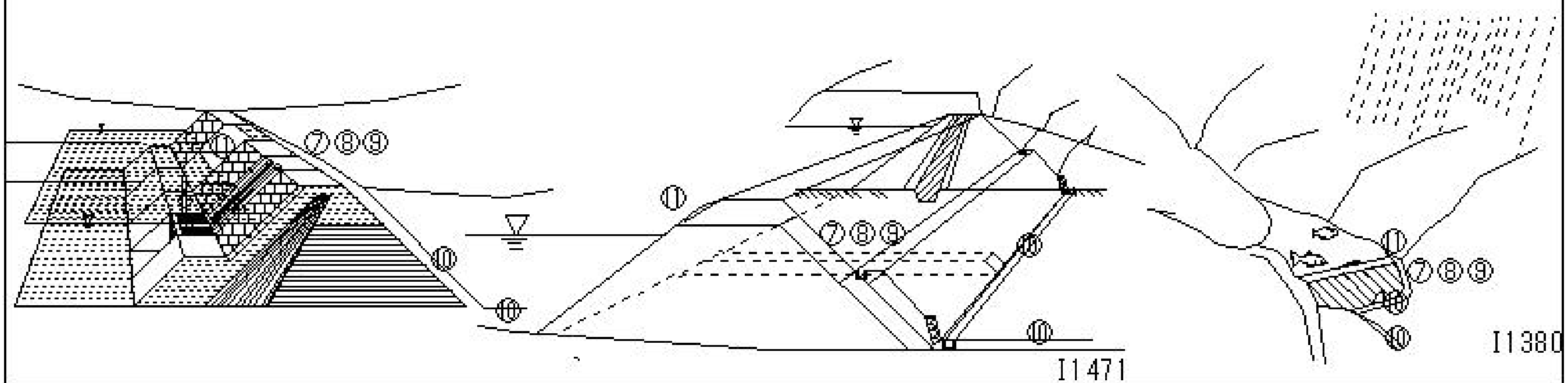
⑦ Spring water is seen from cracks on the surface of the channel concrete.
There are also areas where the rebar is exposed.

⑧ The top of the channel wall is bulging, and it is bending inward.

⑨ Severe wear and damage is seen on the bottom slab and side walls of the channel.

⑩ Overgrowth of vegetation is observed in the spillway or in the downstream waterway.

⑪ Gaps are observed at the boundary between the concrete (spillway) and the embankment.



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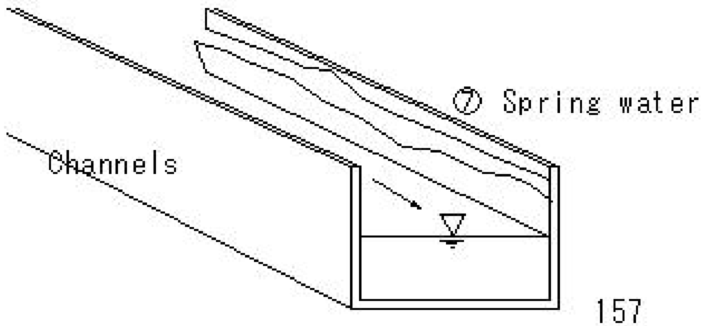
Daily Management

Inspection Checklist　Spillway

⑦ Spring water is seen from cracks on the surface of the channel concrete.
There are also areas where the rebar is exposed.



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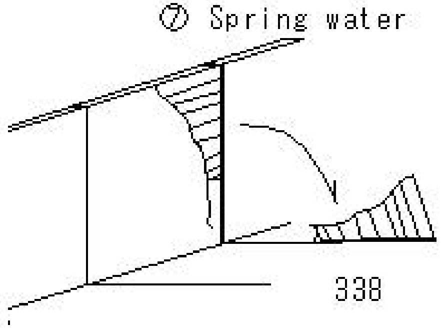

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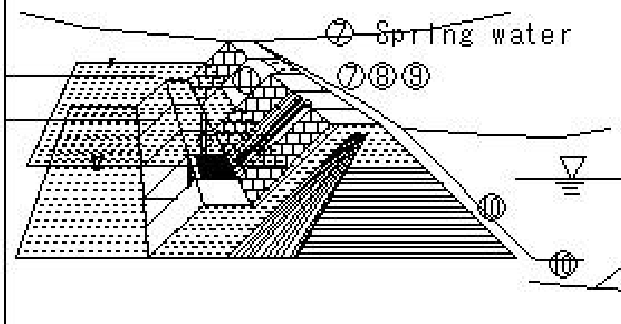
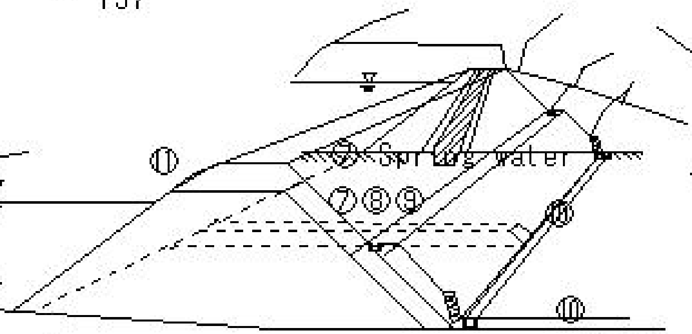
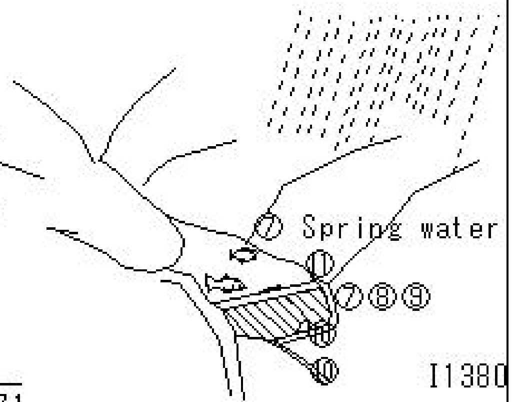




I1471



I1380

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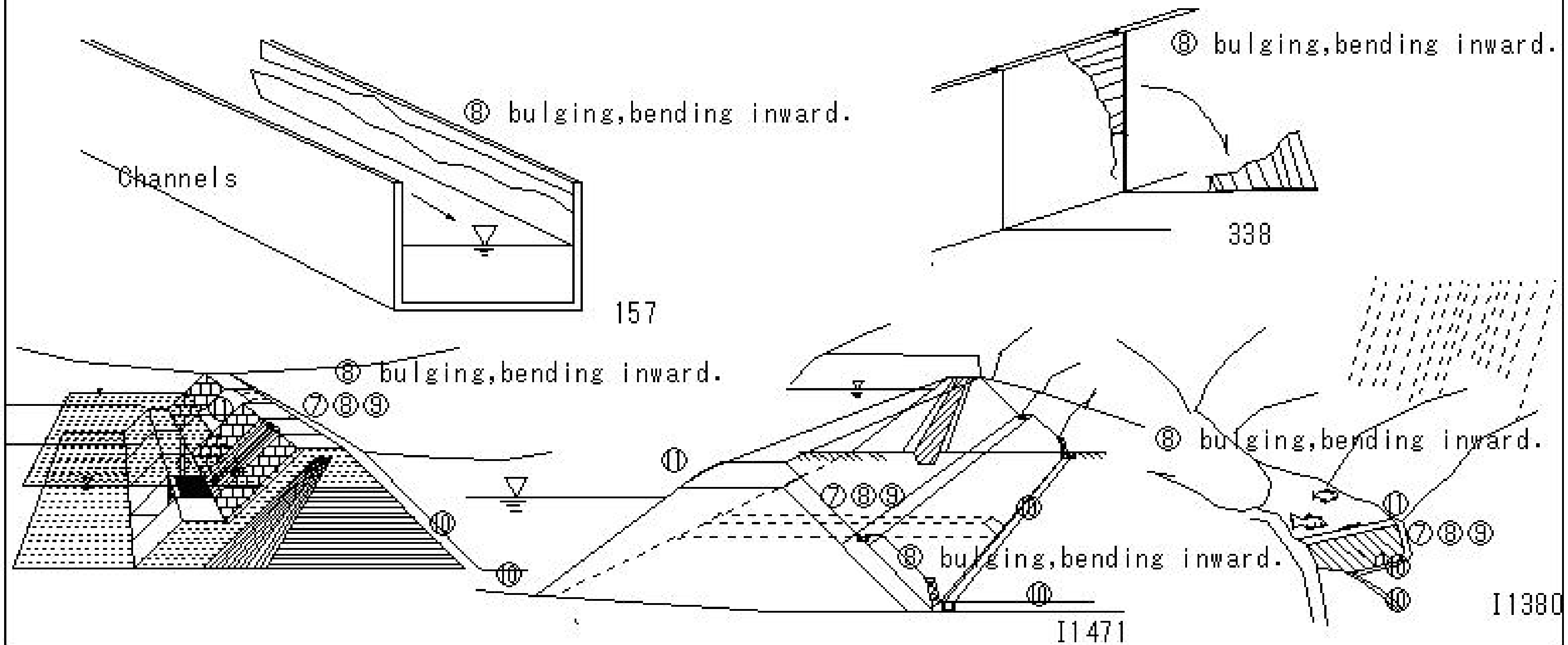
Daily Management

Inspection Checklist　Spillway

⑧ The top of the channel wall is bulging, and it is bending inward.



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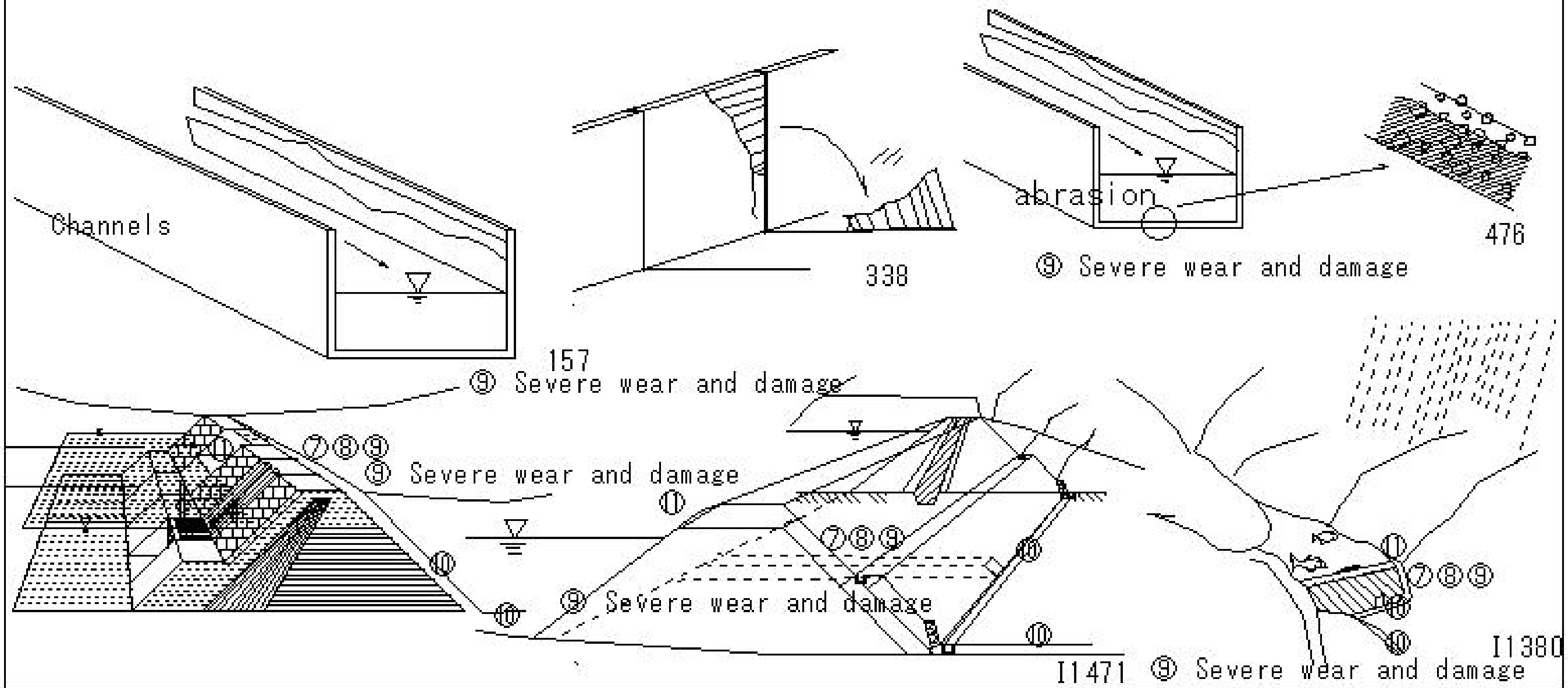
Daily Management

Inspection Checklist Spillway

⑨ Severe wear and damage is seen on the bottom slab and side walls of the channel.



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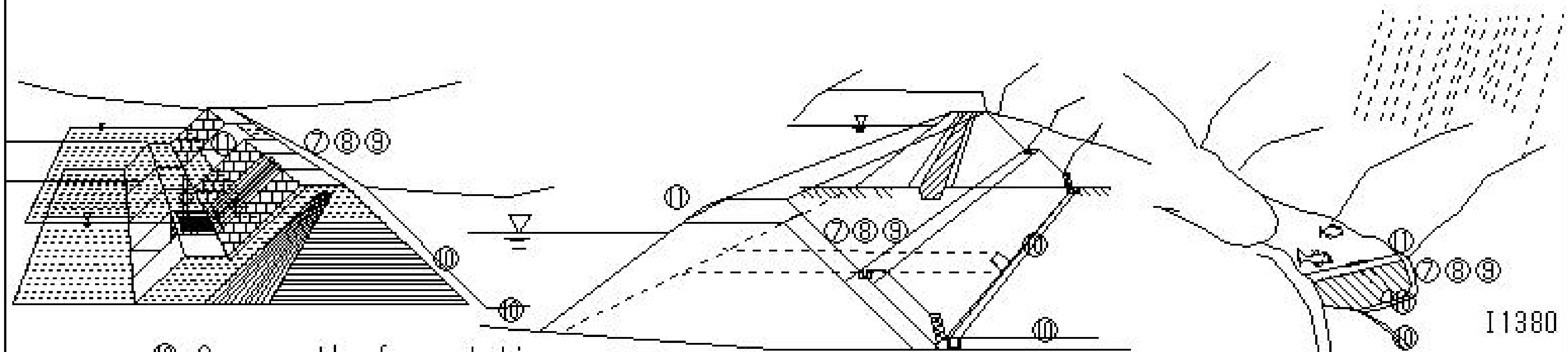
Daily Management

Inspection Checklist Spillway

⑩ Overgrowth of vegetation is observed in the spillway or in the downstream waterway.



⑩ Overgrowth of vegetation

I1471 ⑩ Overgrowth of vegetation

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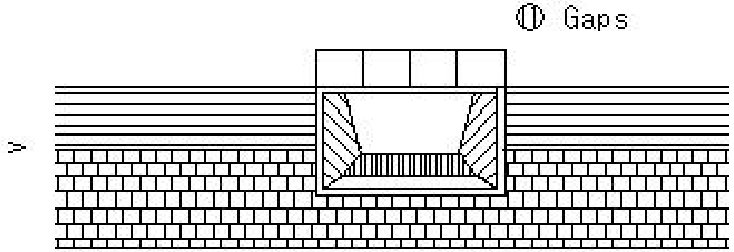
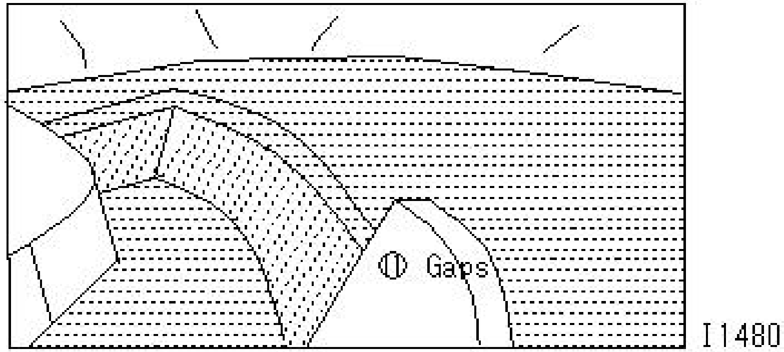
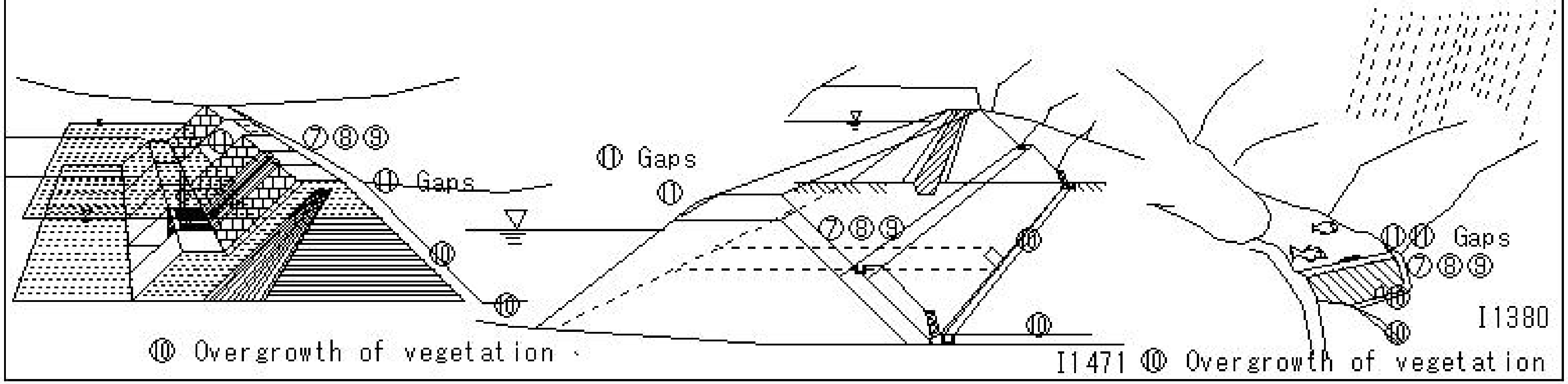
Daily Management

Inspection Checklist Spillway

⑪ Gaps are observed at the boundary between the concrete (spillway) and the embankment.







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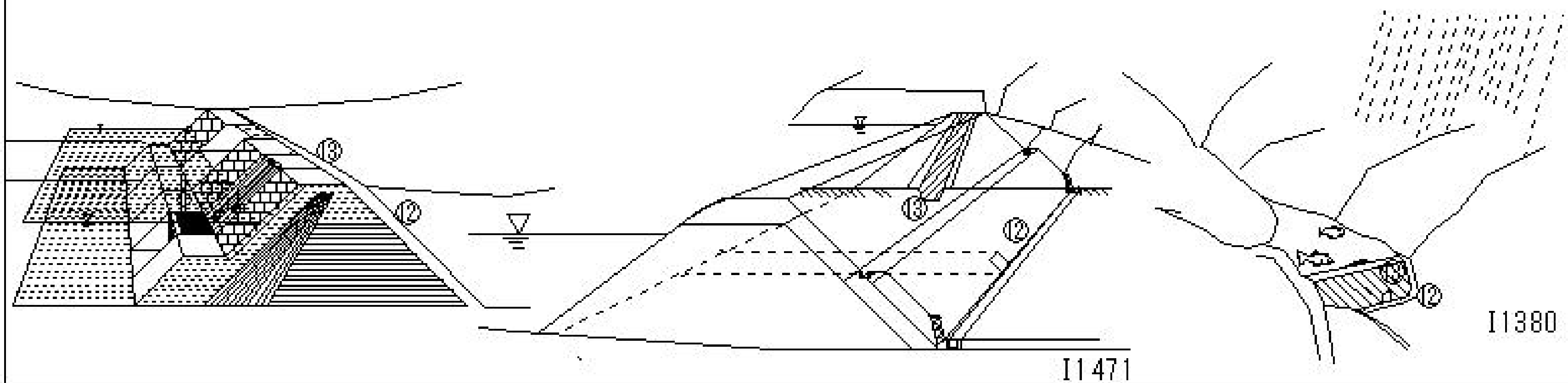
Daily Management

Inspection Checklist Observation facilities

⑫ Leakage has recently increased sharply despite no rain/Leakage has become cloudy.

⑬ Water level measurements within the embankment showed values that differed from previous trends.



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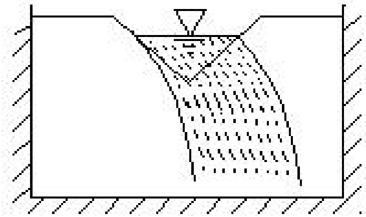
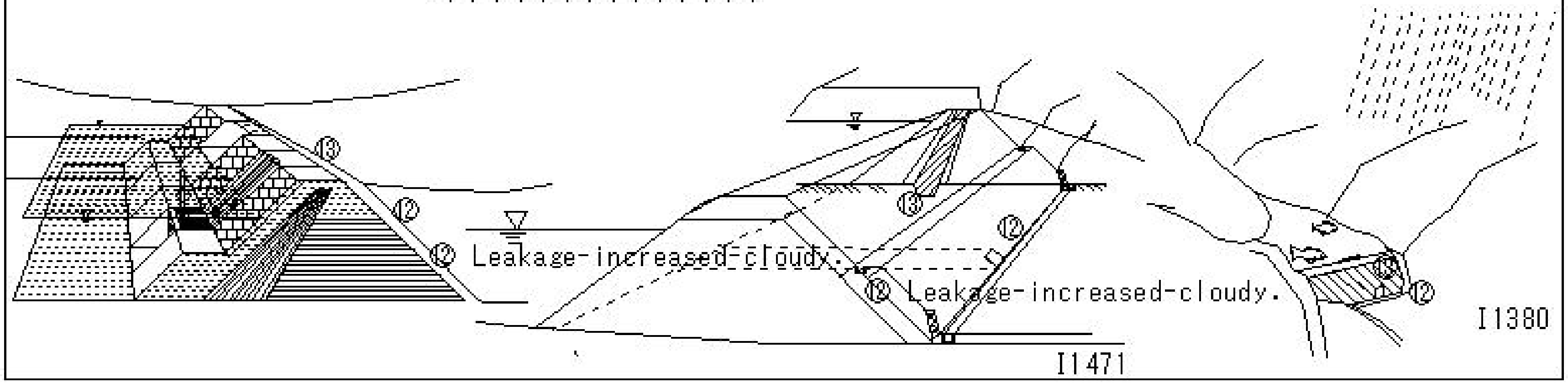
Daily Management

Inspection Checklist Observation facilities

⑫ Leakage has recently increased sharply despite no rain/Leakage has become cloudy.



⑫ Leakage-cloudy.



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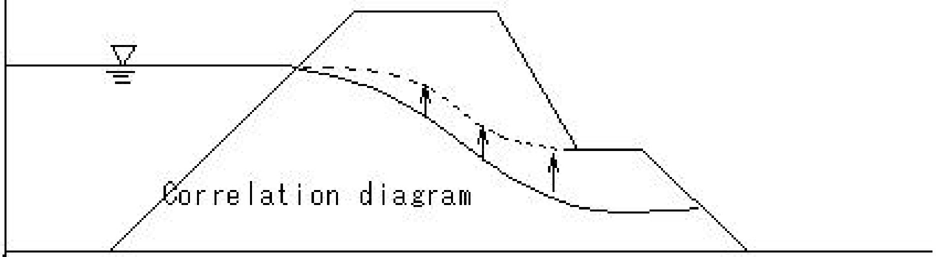
Daily Management

Inspection Checklist Observation facilities

⑬ Water level measurements within the embankment showed values that differed from previous trends.



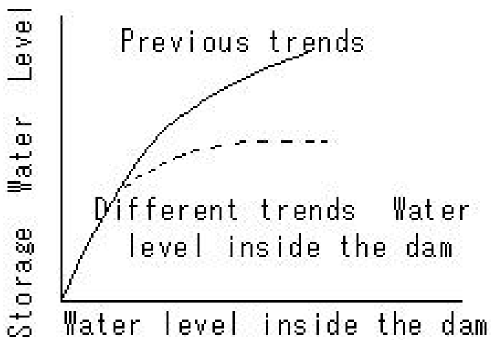
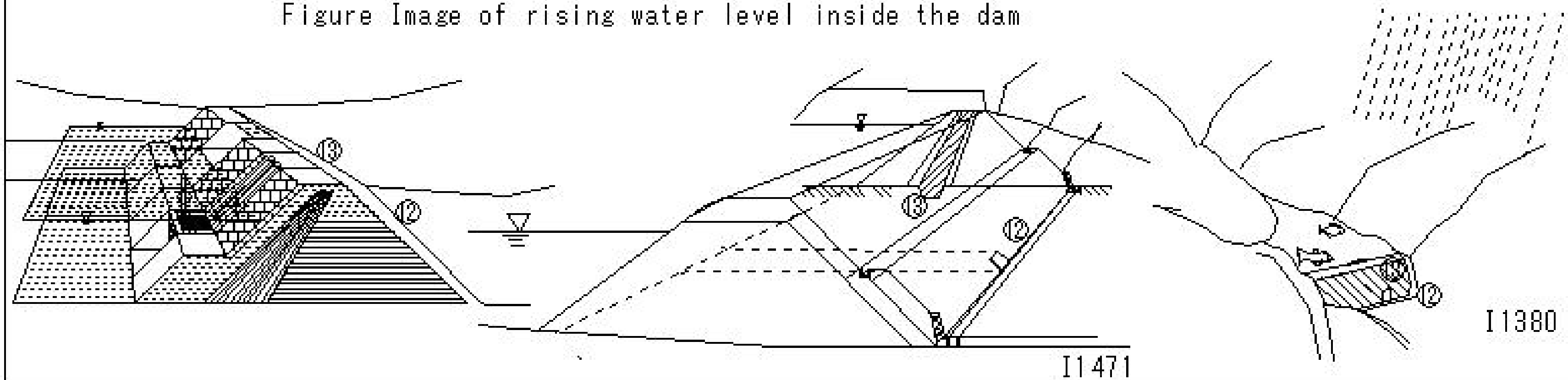


Figure Image of rising water level inside the dam



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Daily Management

Inspection Checklist Intake facilities

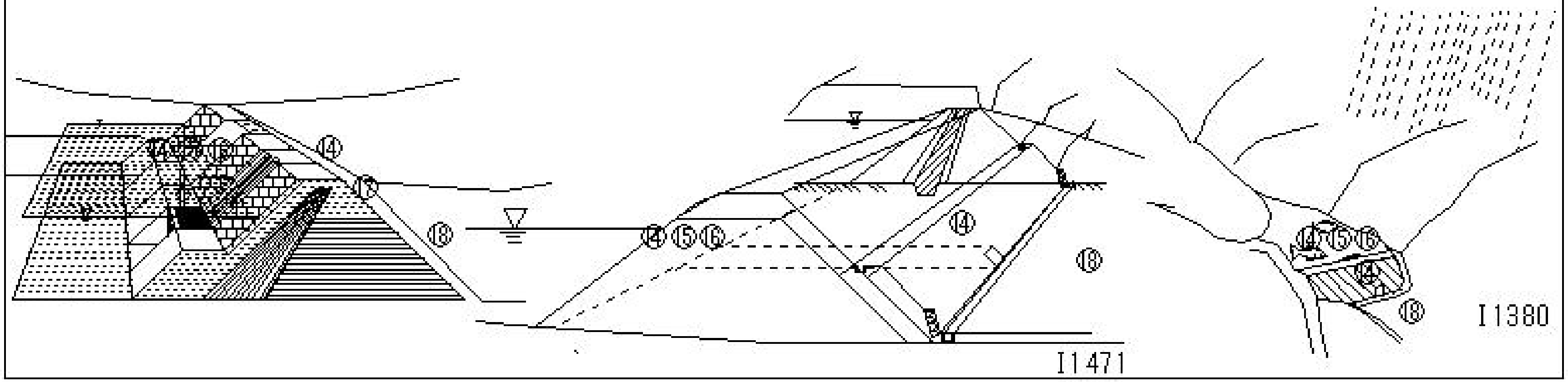
⑭ Damaged inclined gutter. Bottom gutter is damaged or water flow is obstructed.

⑮ Gaps are observed at the boundary between the concrete (inclined gutter) and the embankment.

⑯ Leakage has occurred around the gate, and soil and garbage have accumulated in the surrounding area.

⑰ Muddy water is coming out of the bottom gutter outlet even though the intake gate is fully closed.

⑱ Wetlands and puddles are observed in the downstream ground.



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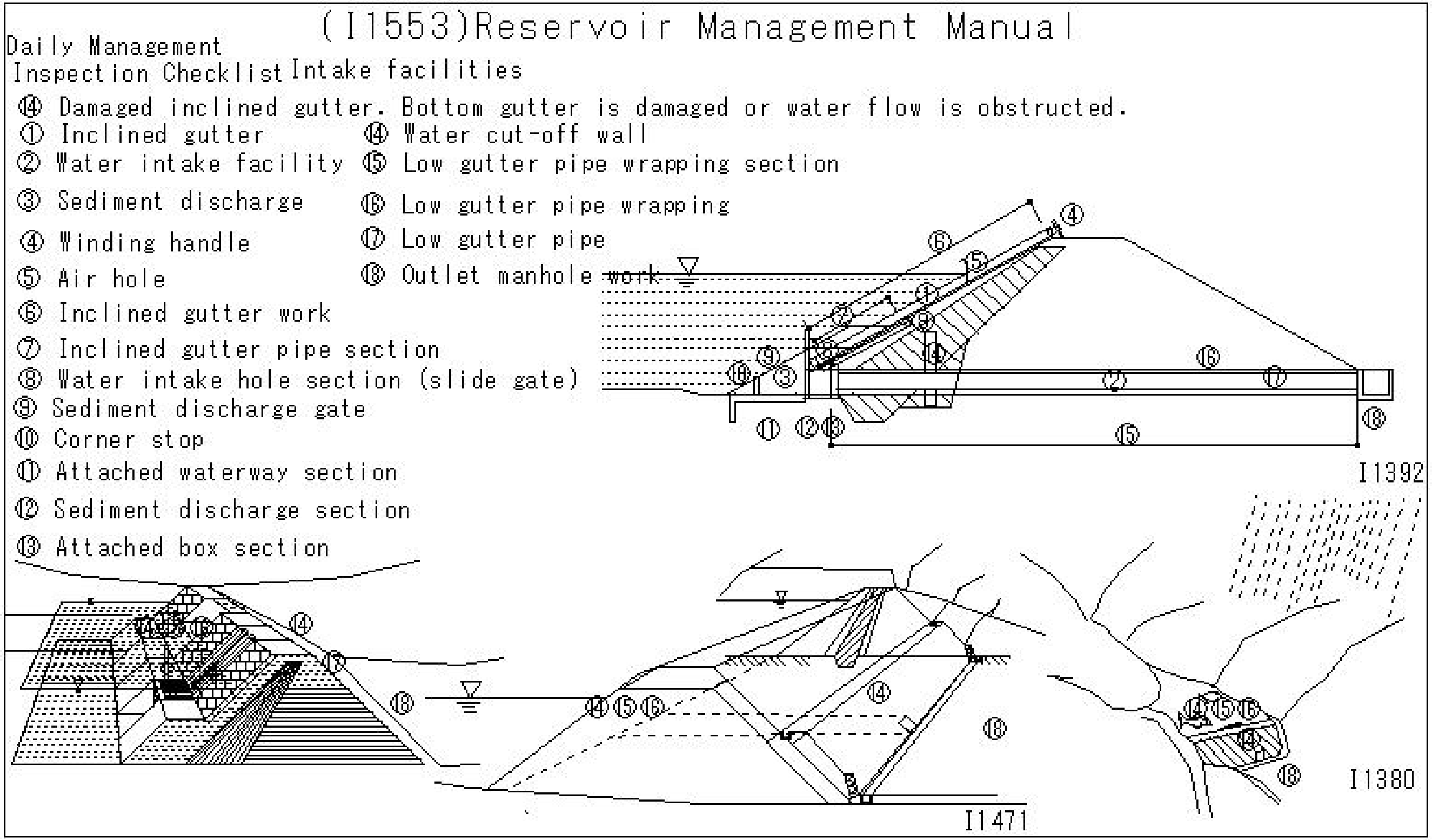

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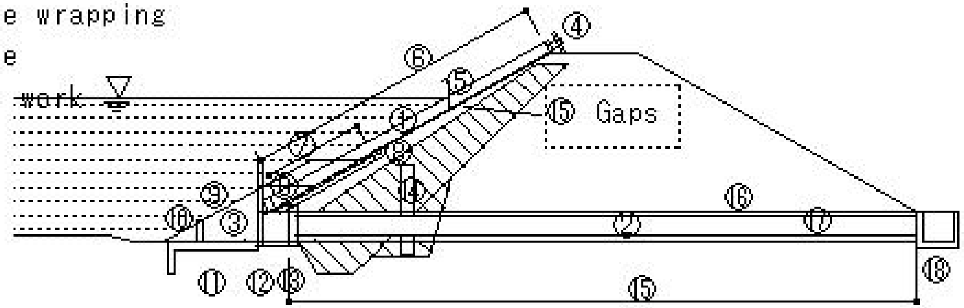
Daily Management Inspection Checklist Intake facilities

⑮ Gaps are observed at the boundary between the concrete (inclined gutter) and the embankment.

① Inclined gutter
② Water intake facility
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gate
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work



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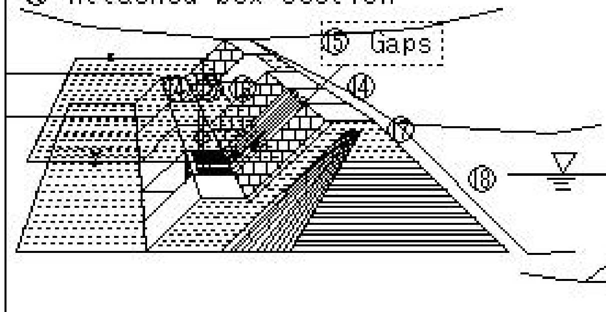

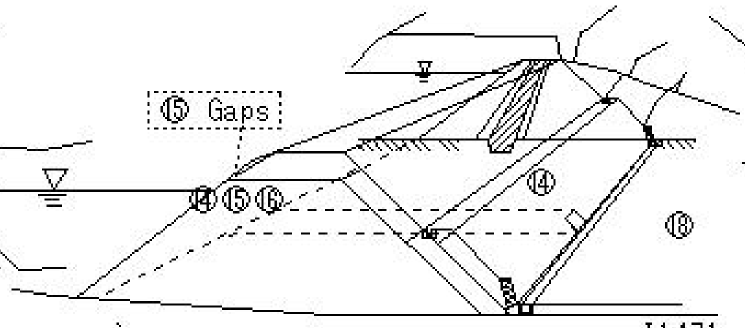

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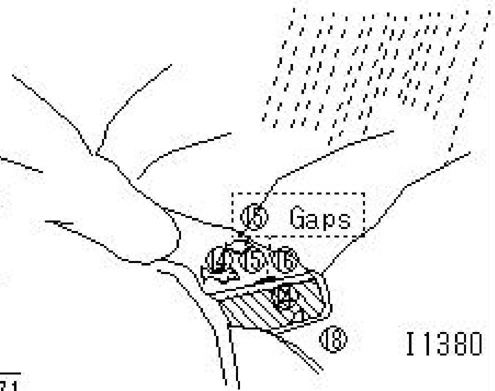
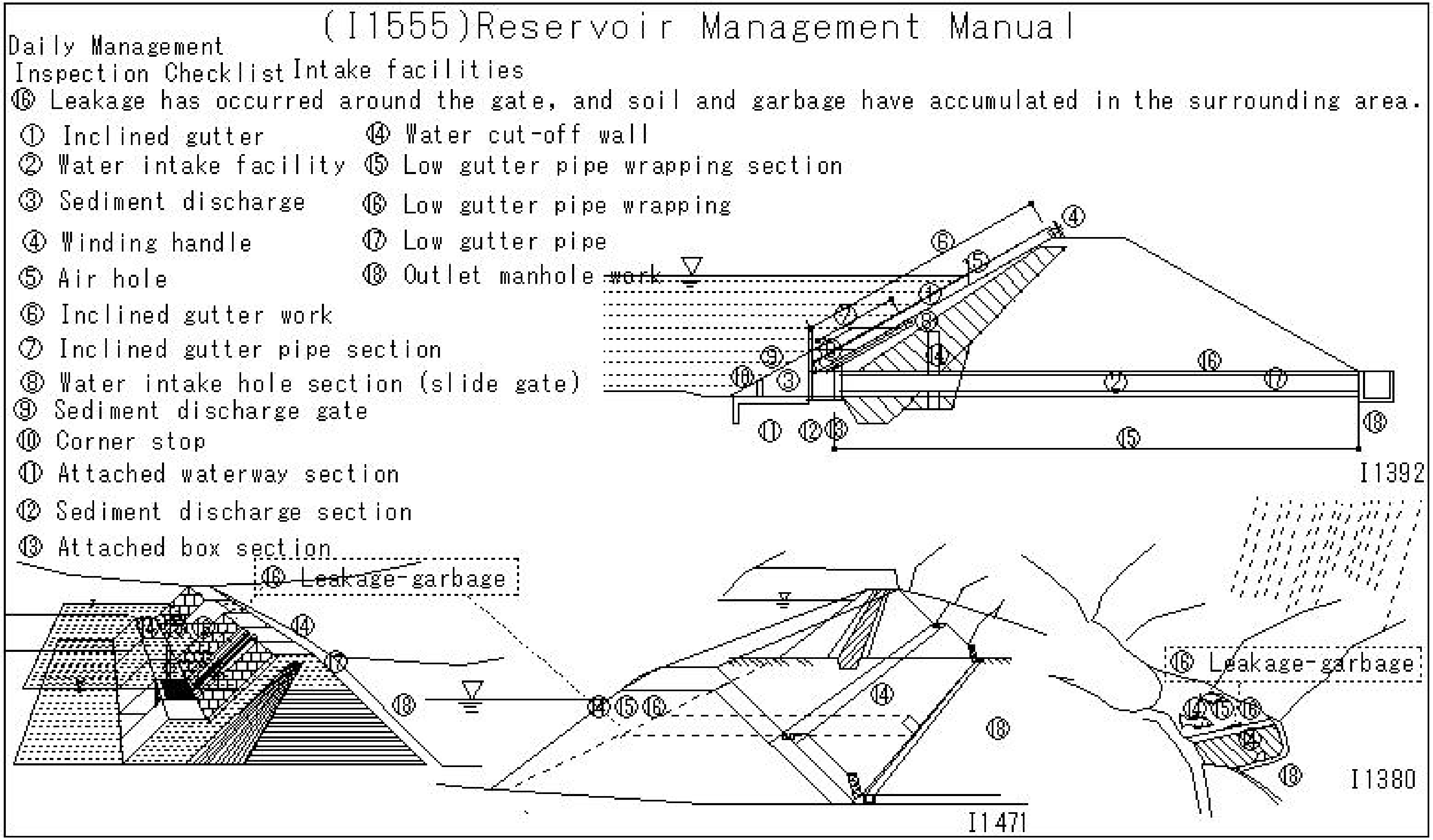


I1380

(I1555)Reservoir Management Manual



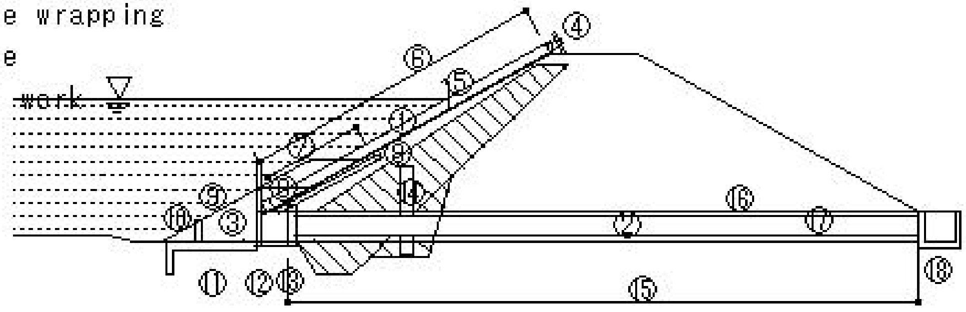
(I1556)Reservoir Management Manual

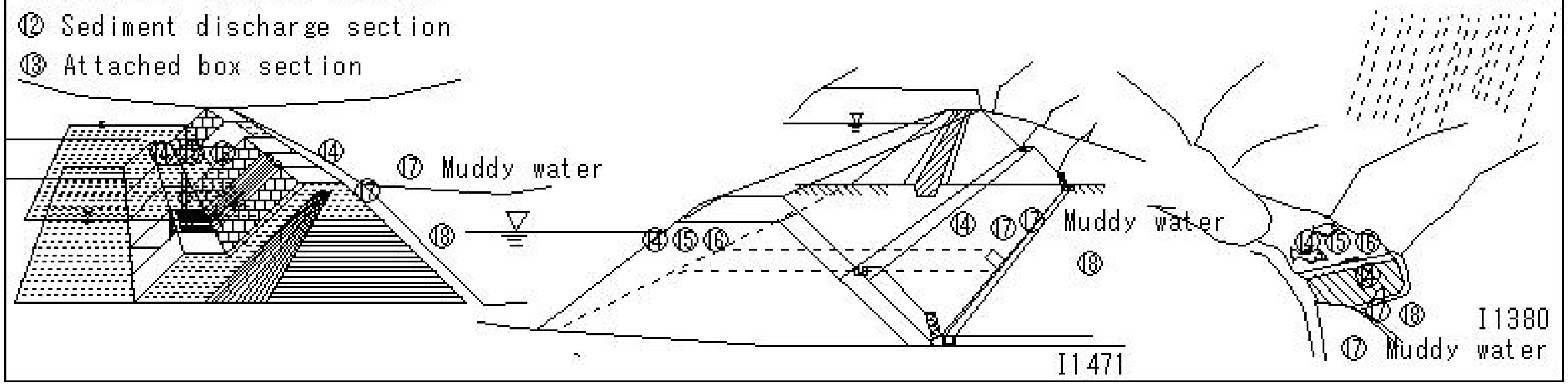
(I1556)Reservoir Management Manual

Daily Management Inspection Checklist Intake facilities

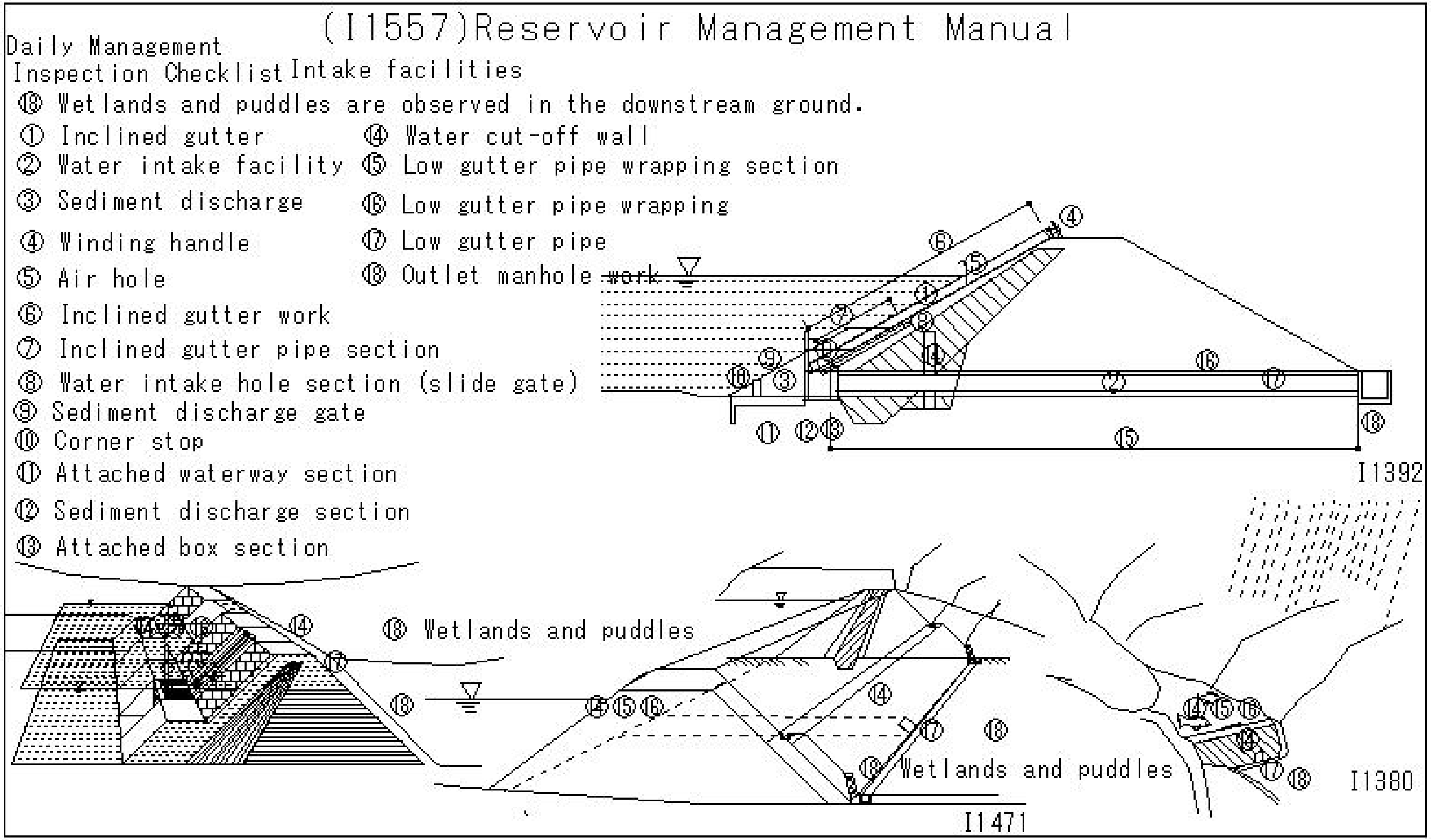
⑰ Muddy water is coming out of the bottom gutter outlet even though the intake gate is fully closed.

① Inclined gutter
② Water intake facility
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gate
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work





(I1557)Reservoir Management Manual



(I1558)Reservoir Management Manual

(I1558)Reservoir Management Manual

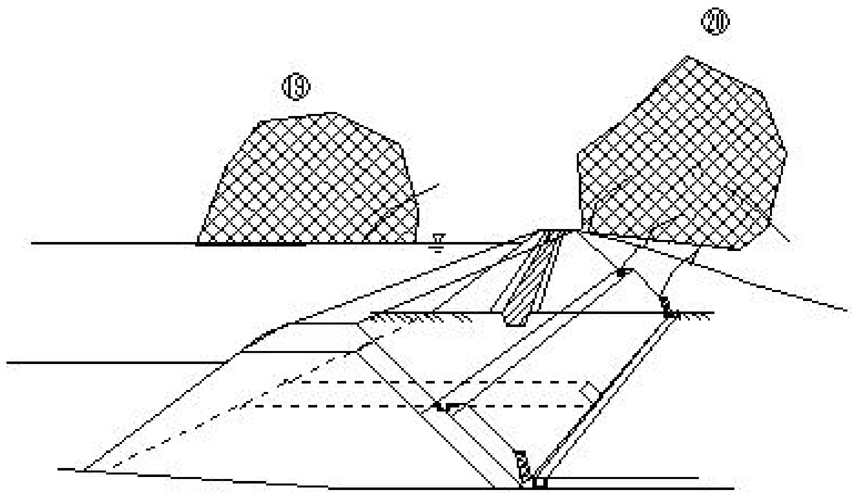
Daily Management

Inspection Checklist

Slopes and embankments within the reservoir and around the embankment

⑲ There are areas within the reservoir where large-scale slope collapses and continuous cracks and springs have occurred.

⑳ There are areas on the slope close to the embankment where continuous cracks and springs have occurred.



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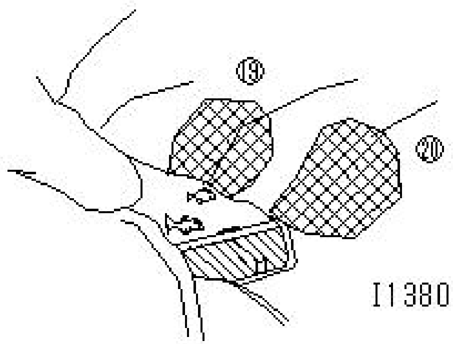


I1380

Check points for the slopes around the reservoir and embankment

(I1559)Reservoir Management Manual

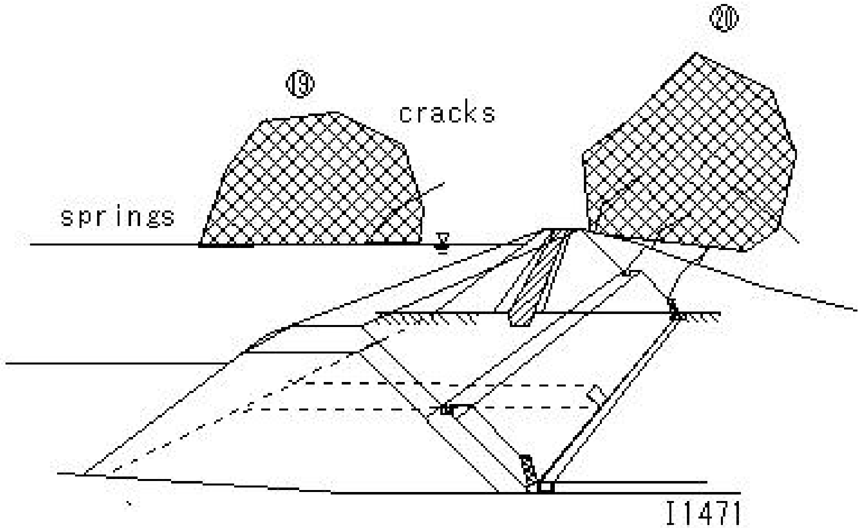
(I1559)Reservoir Management Manual

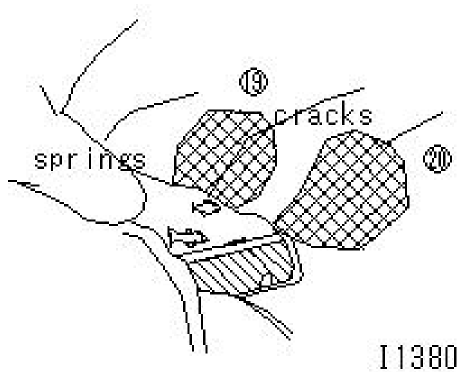
Daily Management

Inspection Checklist

Slopes and embankments within the reservoir and around the embankment

⑲ There are areas within the reservoir where large-scale slope collapses and continuous cracks and springs have occurred.





Check points for the slopes around the reservoir and embankment

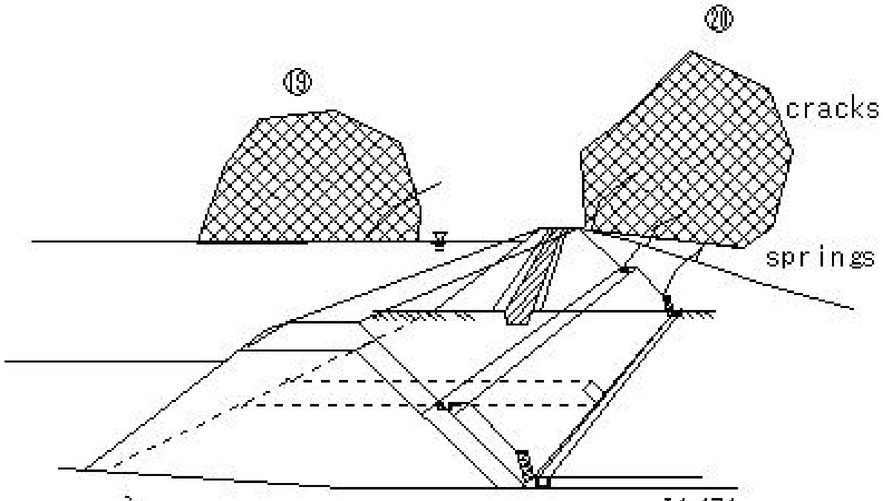
(I1560)Reservoir Management Manual

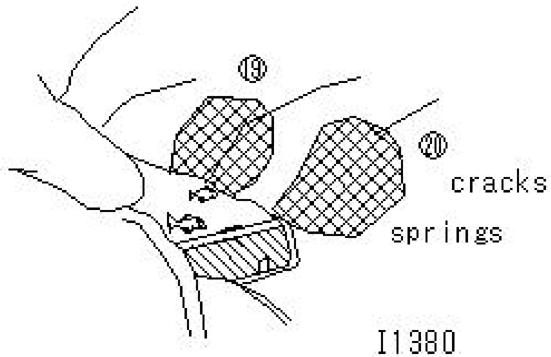
Daily Management

Inspection Checklist

Slopes and embankments within the reservoir and around the embankment

⑳ There are areas on the slope close to the embankment where continuous cracks and springs have occurred.





Check points for the slopes around the reservoir and embankment

(I1561)Reservoir Management Manual

(I1561)Reservoir Management Manual

Daily Management

Inspection Checklist

Embankment

① There are areas where the embankment slope has collapsed, cracked, or bulged out.

② There are areas of damage or erosion in the riprap, stonework, and blocks on the embankment slope.

③ There are changes in vegetation on the downstream slope of the embankment, such as the overgrowth of ferns, butterbur, and moss, which prefer moist soil.

④ Spring water is seen from the edge of the embankment.

⑤ Seeping water, spring water, and sediment are seen on the downstream slope of the embankment and in the berm receiving channel.

⑥ Erosion of the embankment due to drainage from the connecting road is seen.

Spillway

⑦ Spring water is seen from cracks on the surface of the channel concrete.
There are also areas where the rebar is exposed.

⑧ The top of the channel wall is bulging, and it is bending inward.

⑨ Severe wear and damage is seen on the bottom slab and side walls of the channel.

⑩ Overgrowth of vegetation is observed in the spillway or in the downstream waterway.

⑪ Gaps are observed at the boundary between the concrete (spillway) and the embankment.

Observation facilities

⑫ Leakage has recently increased sharply despite no rain/Leakage has become cloudy.

⑬ Water level measurements within the embankment showed values ??that differed from previous trends.

(I1562)Reservoir Management Manual

Daily Management

Inspection Checklist

Intake facilities

⑭ Damaged inclined gutter. Bottom gutter is damaged or water flow is obstructed.

⑮ Gaps are observed at the boundary between the concrete (inclined gutter) and the embankment.

⑯ Leakage has occurred around the gate, and soil and garbage have accumulated in the surrounding area.

⑰ Muddy water is coming out of the bottom gutter outlet even though the intake gate is fully closed.

⑱ Wetlands and puddles are observed in the downstream ground.

Slopes and embankments within the reservoir and around the embankment

⑲ There are areas within the reservoir where large-scale slope collapses and continuous cracks and springs have occurred.

⑳ There are areas on the slope close to the embankment where continuous cracks and springs have occurred.

(I1563)Reservoir Management Manual

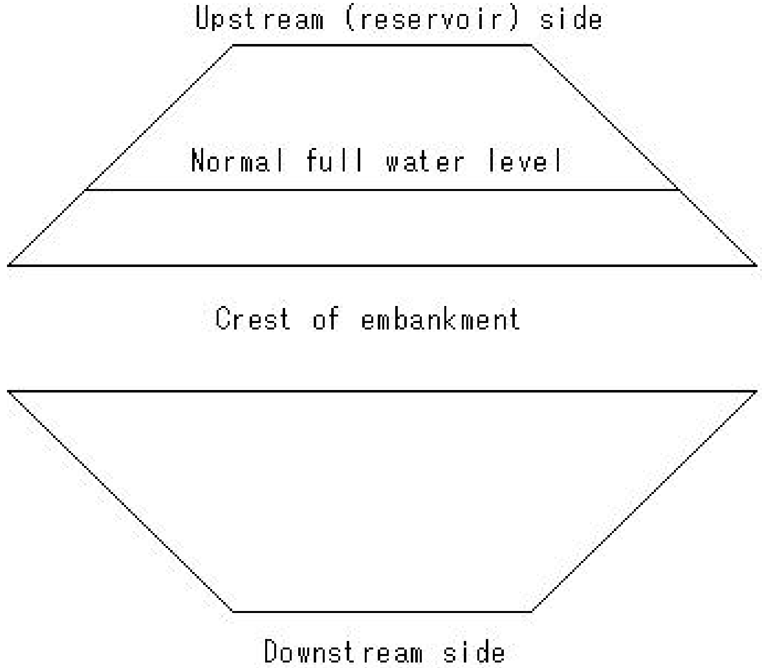
(I1563)Reservoir Management Manual

Daily Management

Record (sketch) of deformation of embankment slope

Survey date (year/month/day)

Reservoir level (   )m



※Sketch the deformation on the diagram, number the deformation, and describe its size and condition.

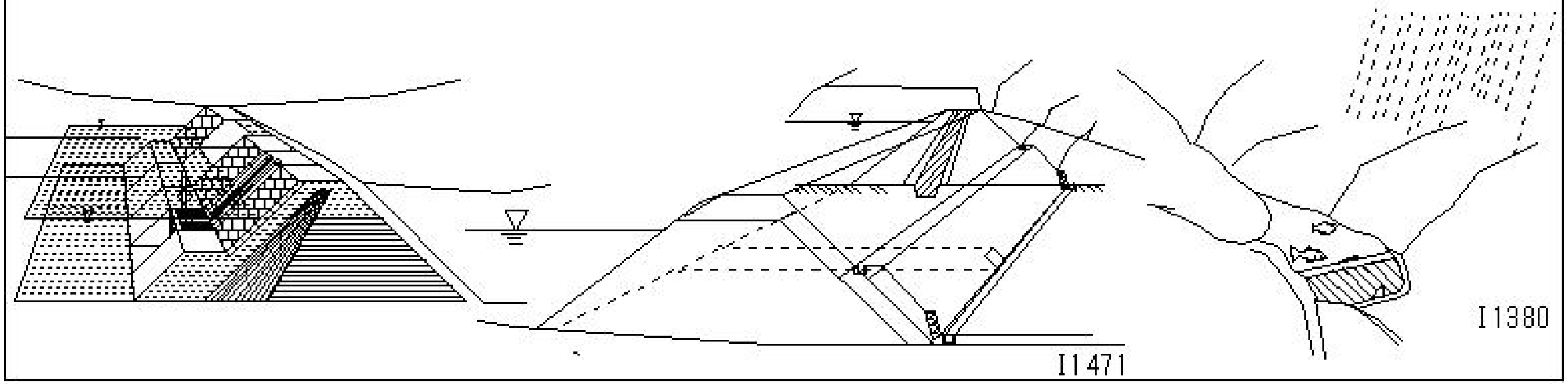
(I1564)Basic knowledge of reservoirs

(I1564) Basic knowledge of reservoirs

Reservoirs

①Securing water for agricultural use and
②Flood control

1. How to design embankments
2. How to design core facilities
3. Important points to note in construction management
4. New construction methods

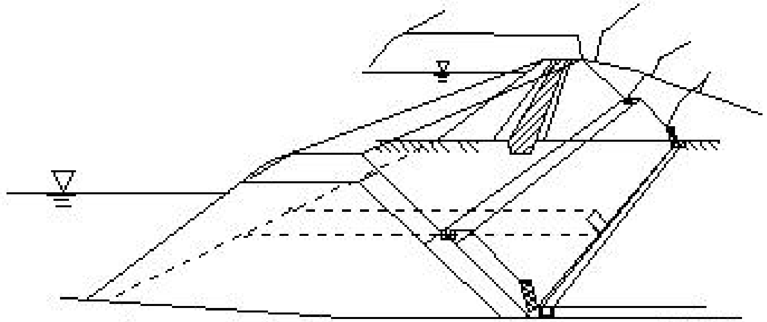


(I1565)Basic knowledge of reservoirs

(I1565) Basic knowledge of reservoirs

1. Embankment design concepts (design considerations)
   - ① The current shape has meaning
   - ② Important structures should be installed on the natural ground
   - ③ Clay soil (embankment) should be consolidated (subsidence)
   - ④ Pay attention to boundaries (piping may occur)

①



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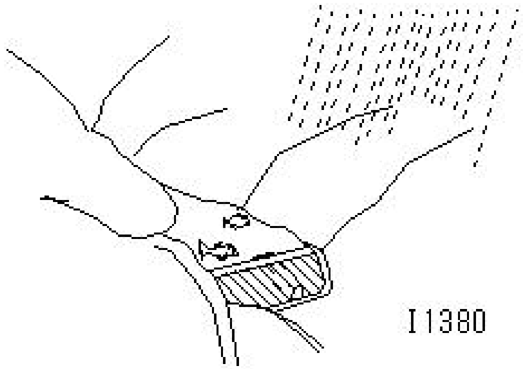
②



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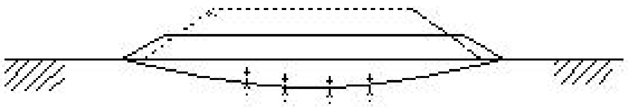
③



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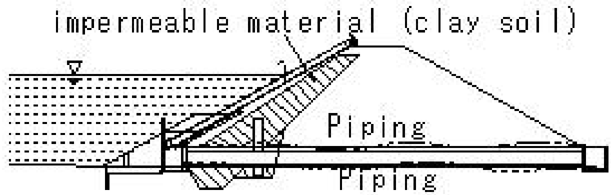
④



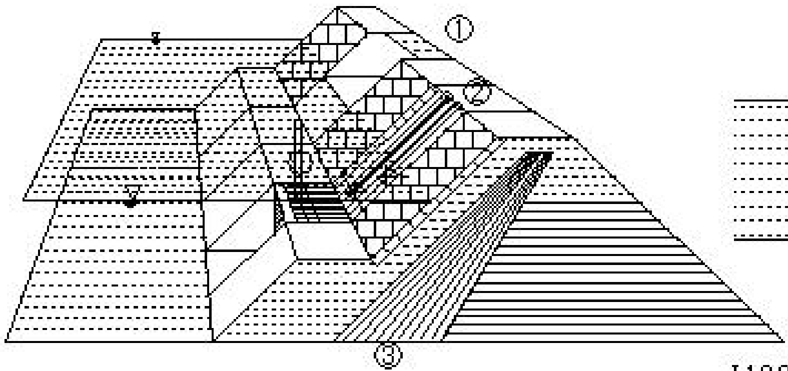
I1449

(I1566)Basic knowledge of reservoirs

(I1566) Basic knowledge of reservoirs

1. Embankment design concept (design guidelines: schematic diagram)

Location ① Spillway ②Water intake facilities ③ impermeable zone



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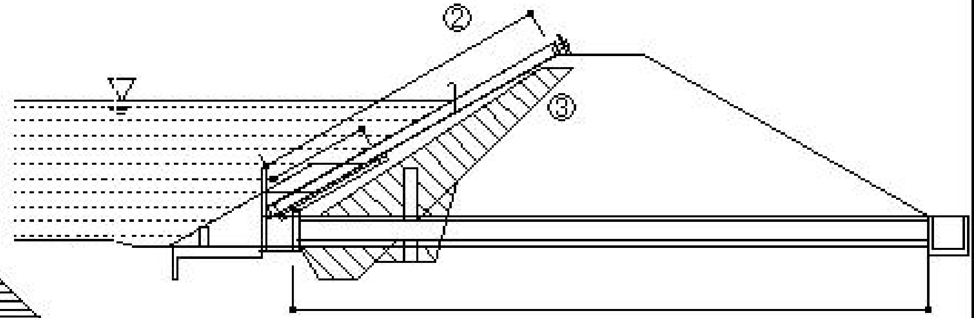

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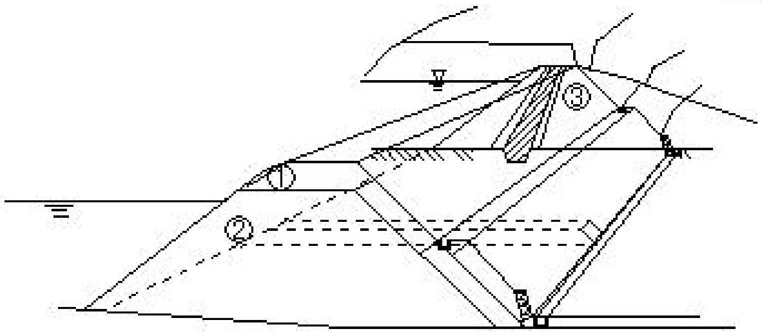

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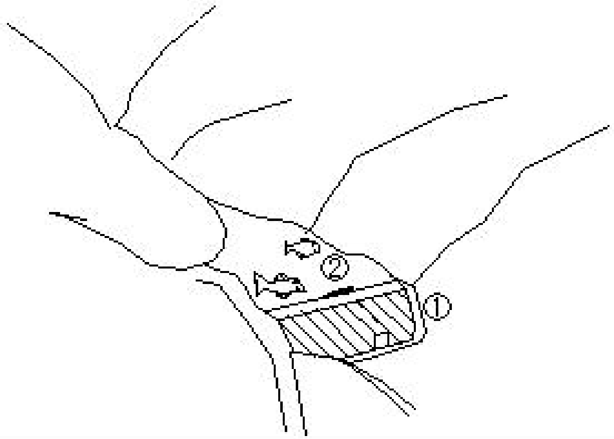


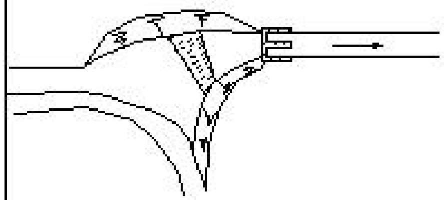
I1380

(I1567)Basic knowledge of reservoirs

(I1567) Basic knowledge of reservoirs

1. Embankment design concept (design guidelines: schematic diagram)

Location ① Spillway



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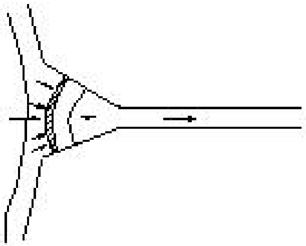

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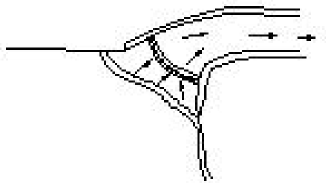
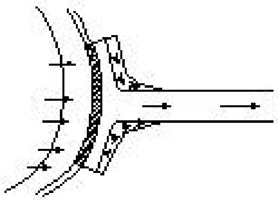


I65

I66



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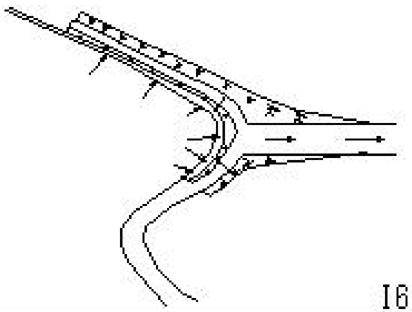

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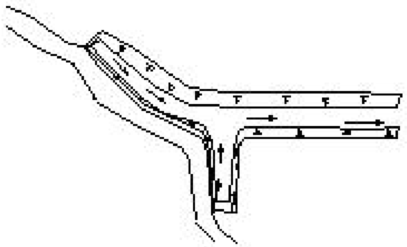

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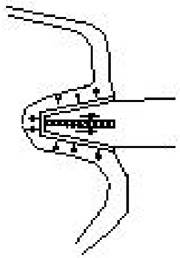


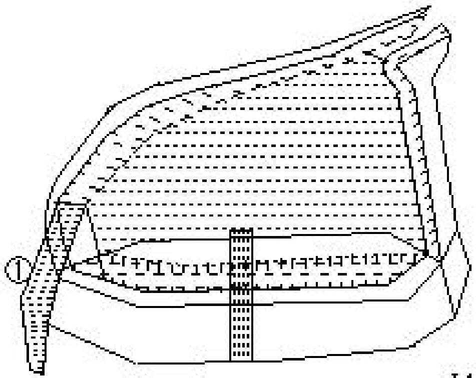
I71

(I1568)Basic knowledge of reservoirs

(I1568) Basic knowledge of reservoirs

1. Embankment design concept (design guidelines: schematic diagram)

① Spillway



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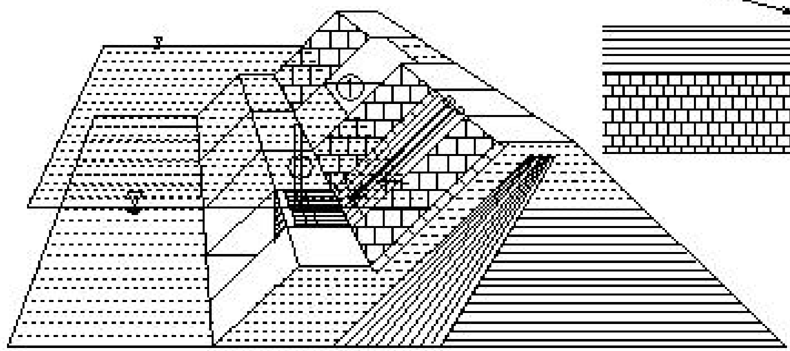

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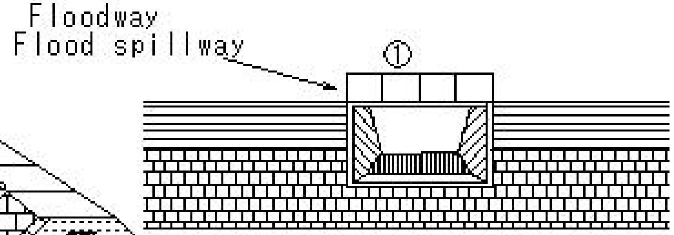

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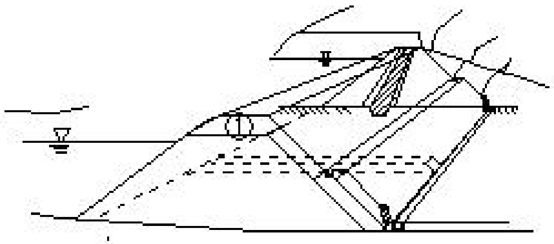

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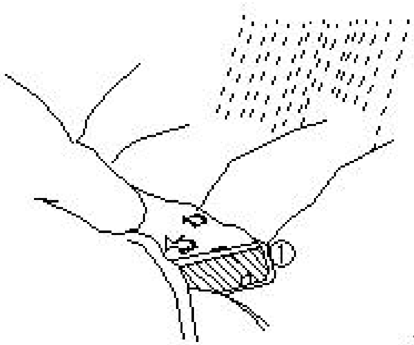

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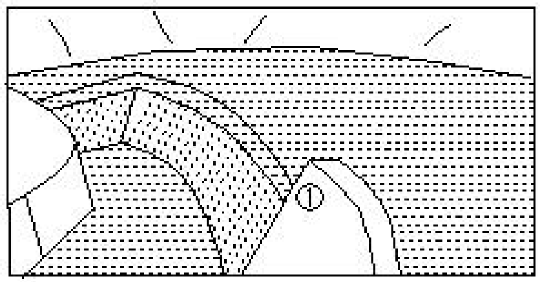


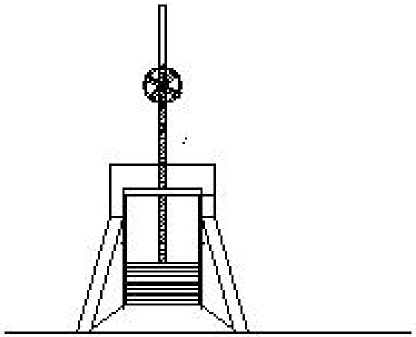
I1479

(I1569)Basic knowledge of reservoirs

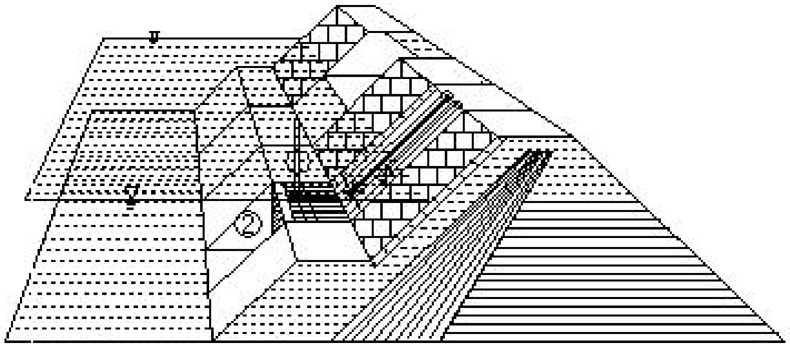
(I1569) Basic knowledge of reservoirs

1. Embankment design concept (design guidelines: schematic diagram)

②Water intake facilities



Sediment discharge gate



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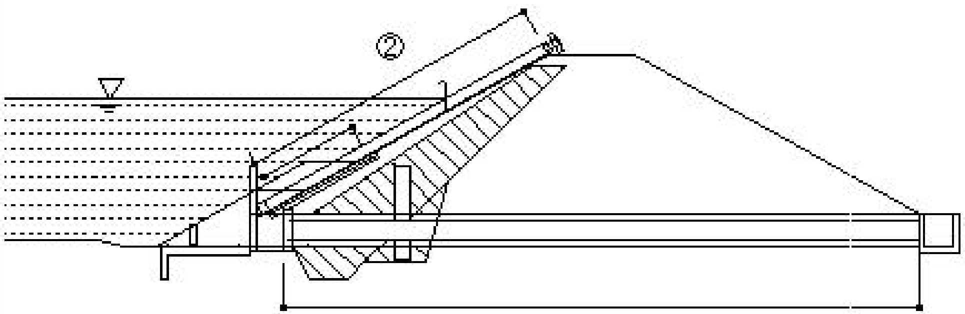

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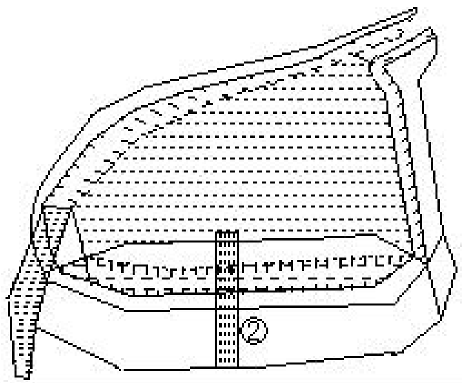


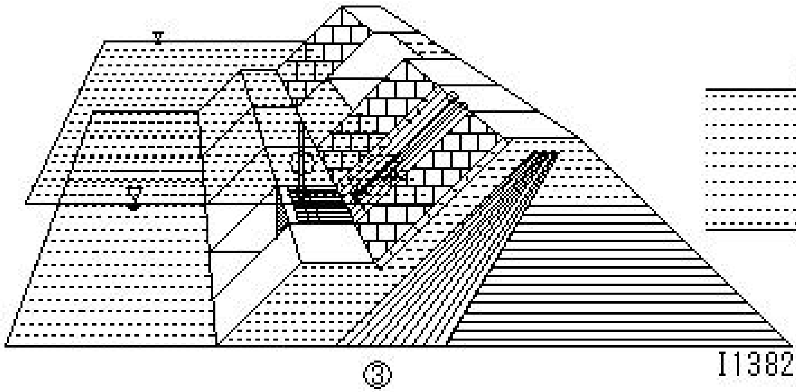
I1386

(I1570)Basic knowledge of reservoirs

(I1570) Basic knowledge of reservoirs

1. Embankment design concept (design guidelines: schematic diagram)

③ impermeable zone



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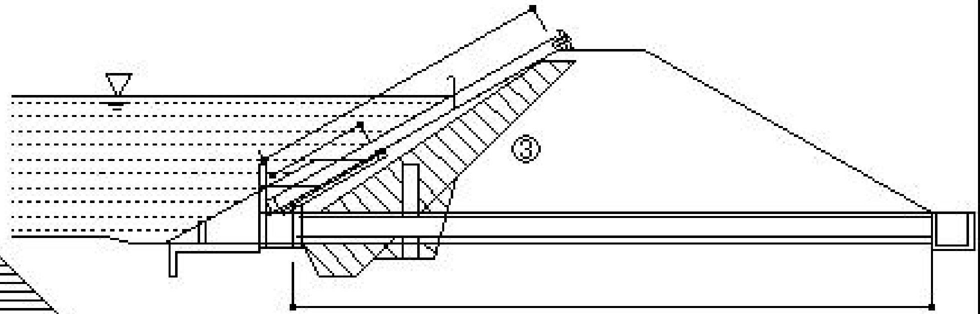

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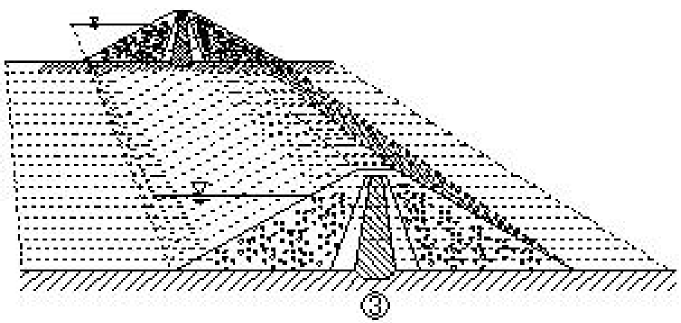

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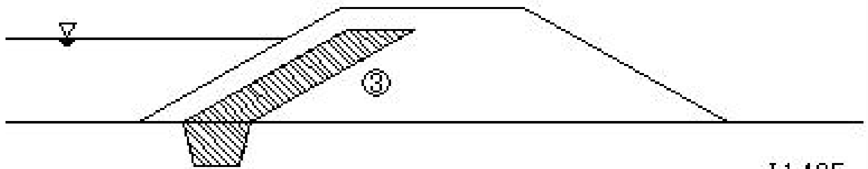

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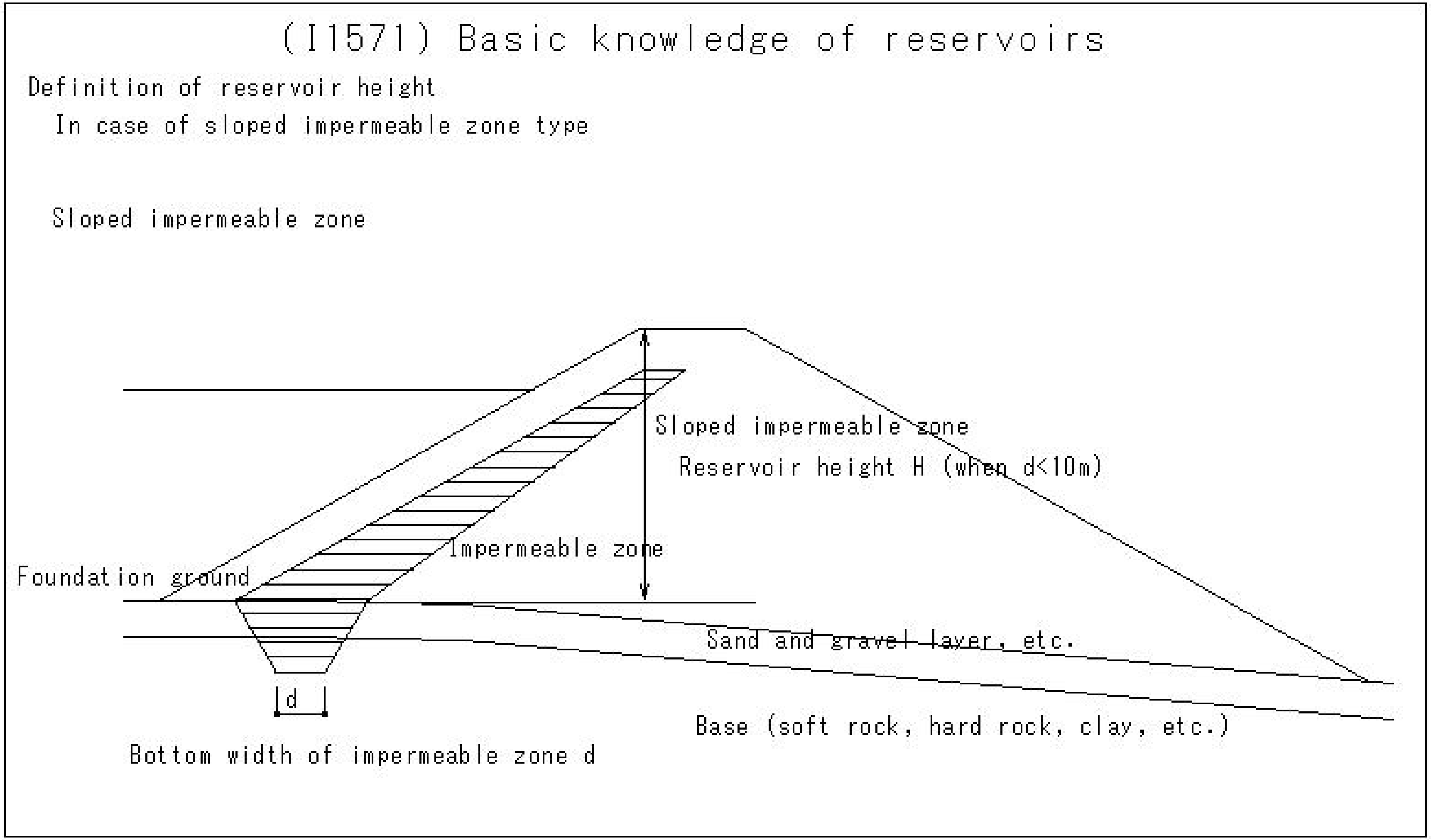
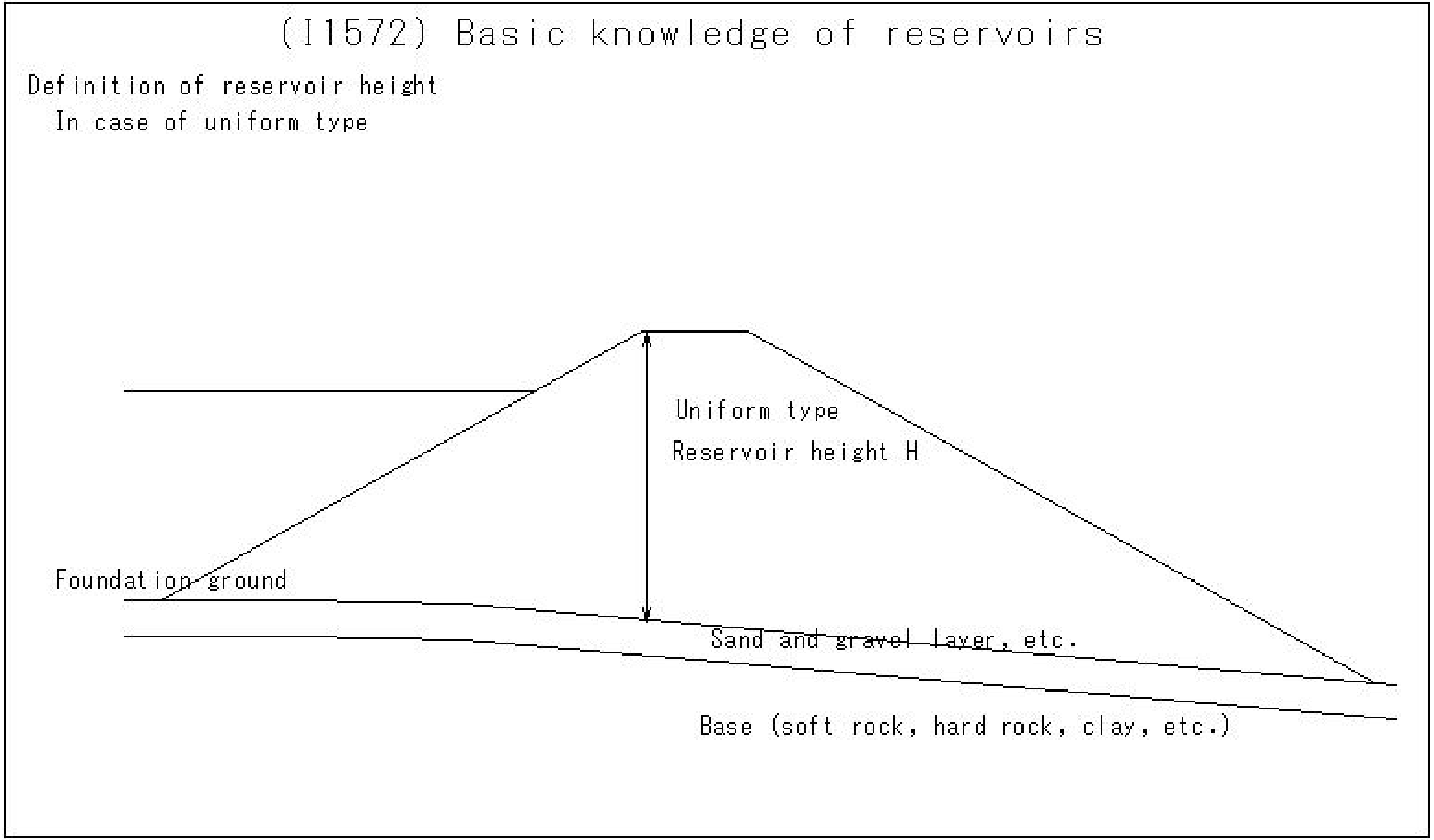
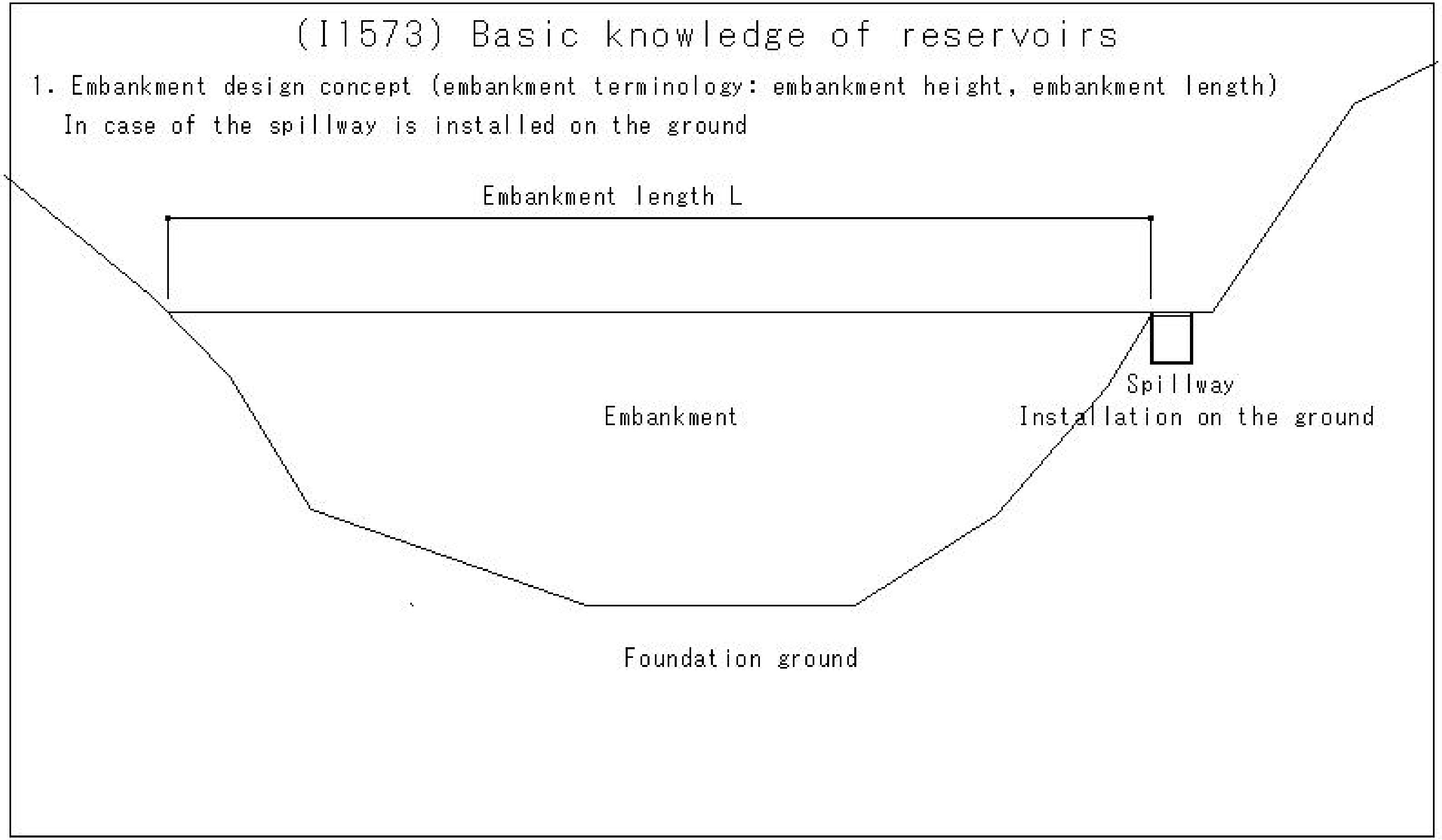
(I1571)Basic knowledge of reservoirs



(I1572)Basic knowledge of reservoirs



(I1573)Basic knowledge of reservoirs

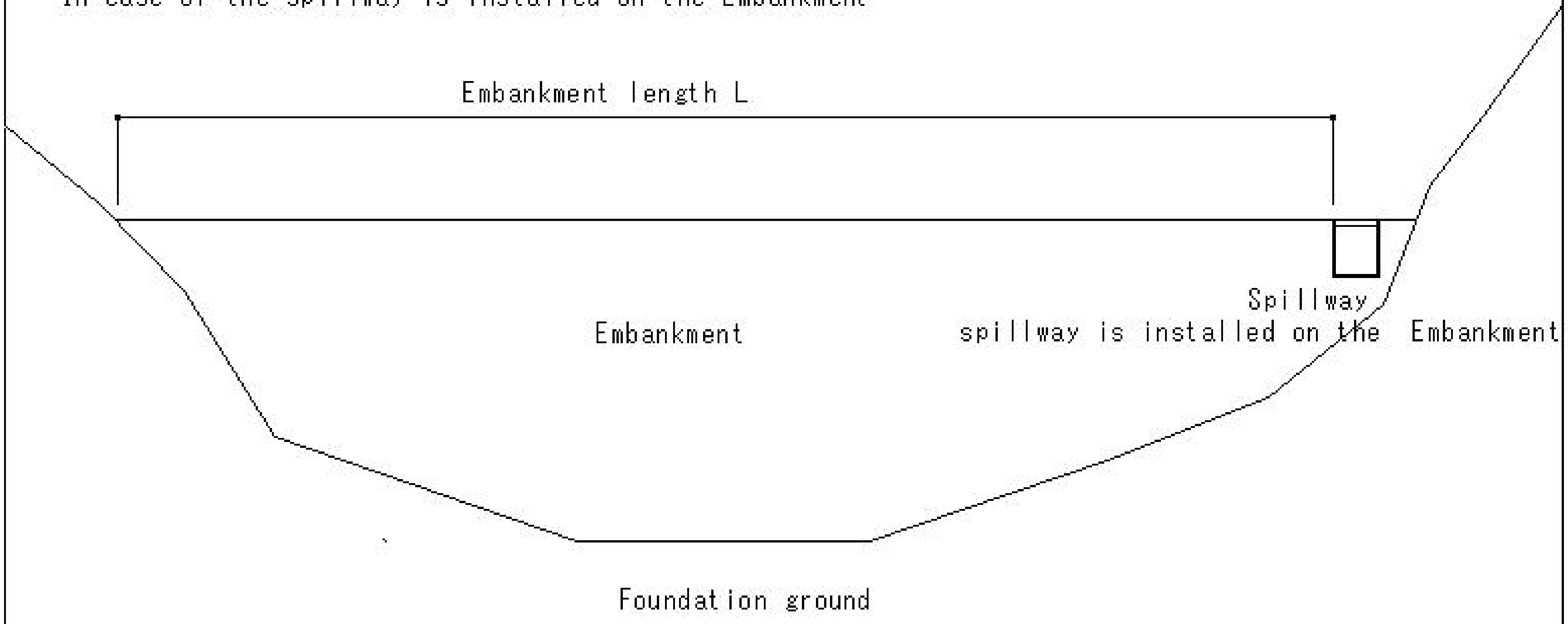


(I1574)Basic knowledge of reservoirs

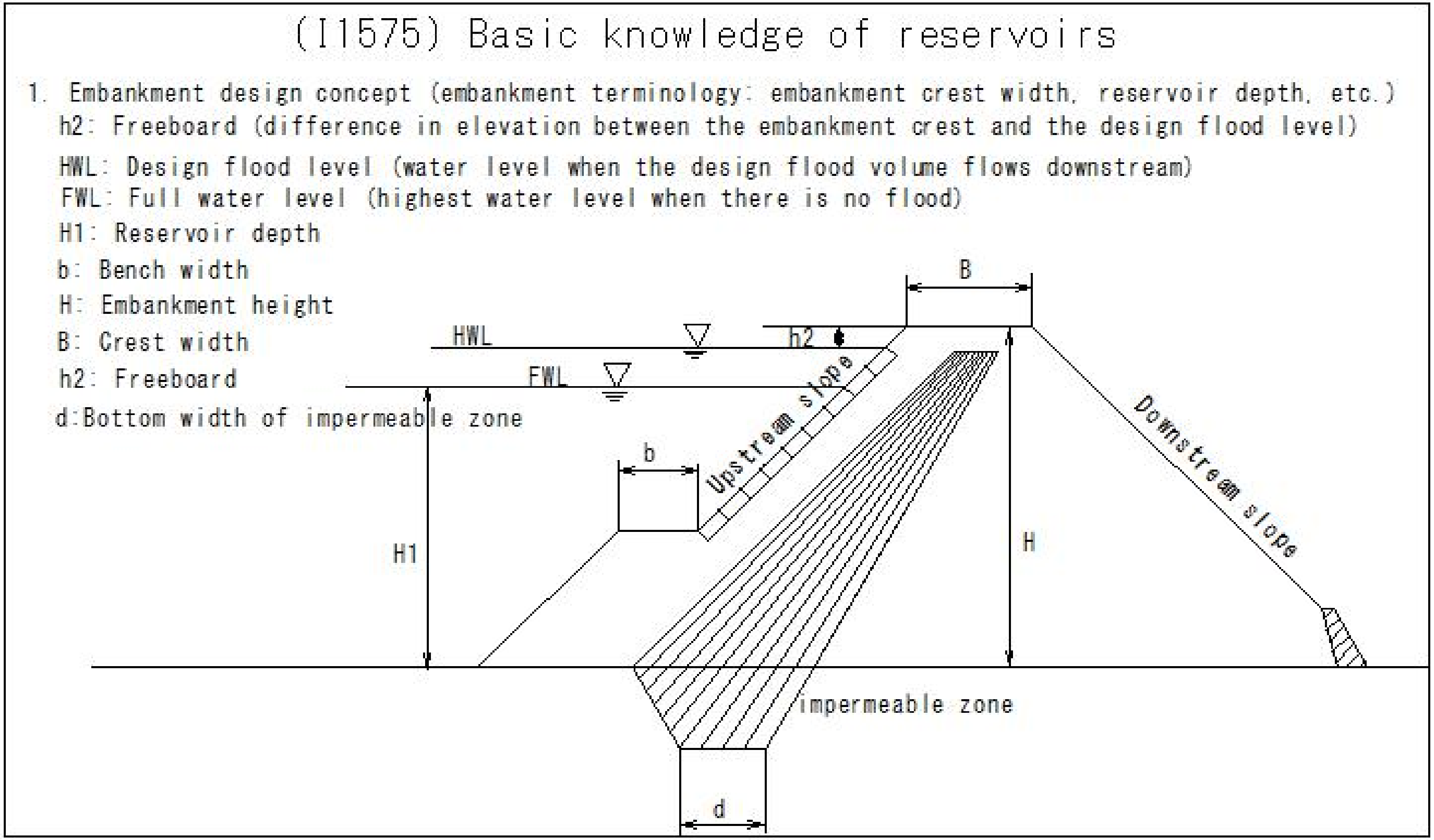
(I1574) Basic knowledge of reservoirs

1. Embankment design concept (embankment terminology: embankment height, embankment length)

In case of the spillway is installed on the Embankment



(I1575)Basic knowledge of reservoirs



(I1576)Basic knowledge of reservoirs

(I1576) Basic knowledge of reservoirs

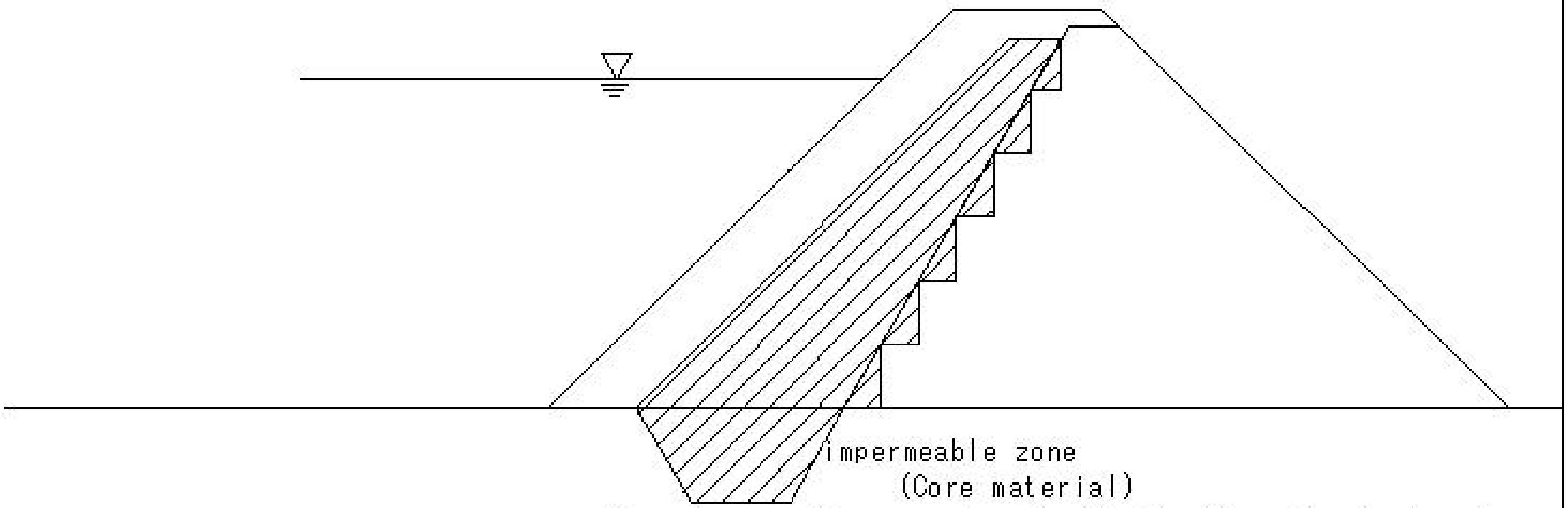
Concept of embankment design (concept of embankment repair method)

Important points in designing an aging reservoir

① Properly judge the deterioration of the current embankment (permeability coefficient, N value)

② Plan to utilize the current embankment as much as possible

The impermeable zone is embedded in the old embankment



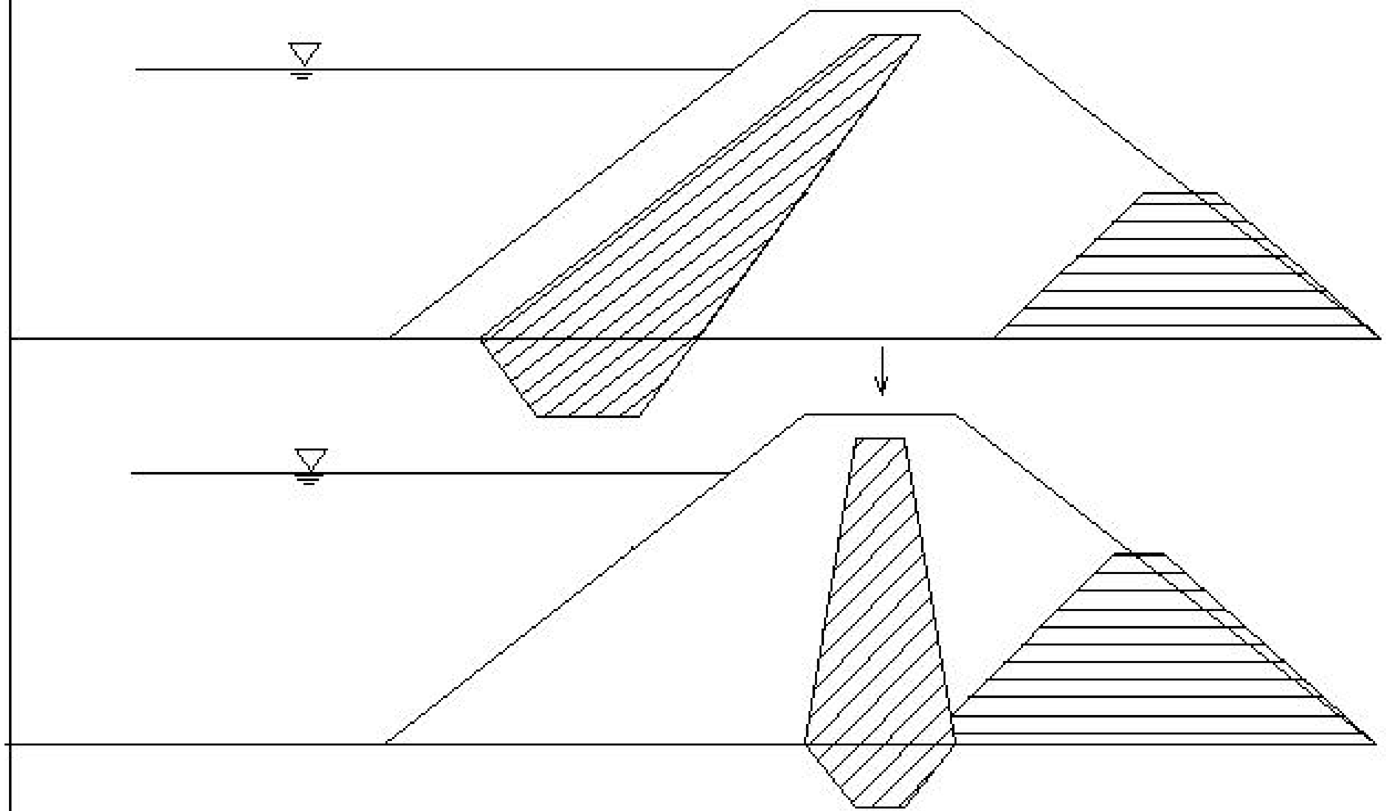
The impermeable zone is embedded in the old embankment

(I1577)Basic knowledge of reservoirs

(I1577) Basic knowledge of reservoirs

Concept of embankment design (concept of embankment repair method)

In case of close to new construction, use the central core

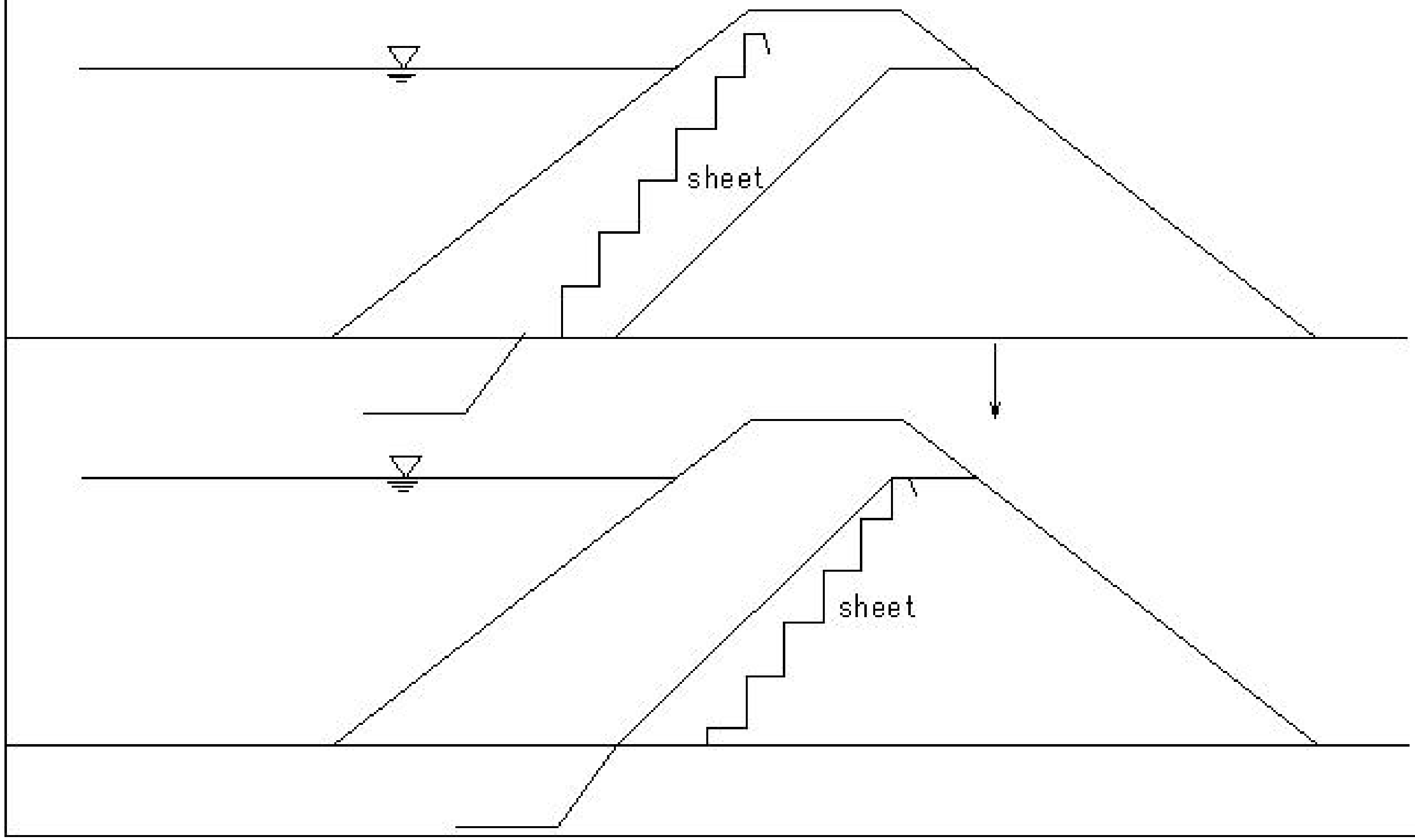


(I1578)Basic knowledge of reservoirs

(I1578) Basic knowledge of reservoirs

Concept of embankment design (concept of embankment repair method)

The sheet is installed on the old embankment

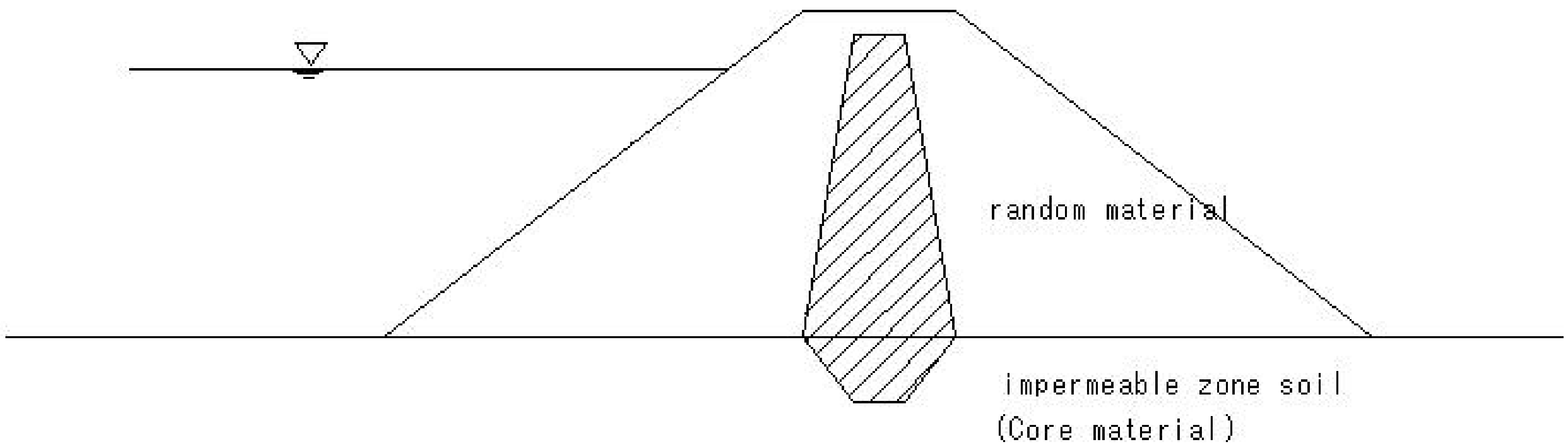


(I1579)Basic knowledge of reservoirs

(I1579) Basic knowledge of reservoirs

Concept of embankment design (concept of embankment repair method)

In case of close to new construction, use the central core



(I1580)Basic knowledge of reservoirs

(I1580) Basic knowledge of reservoirs

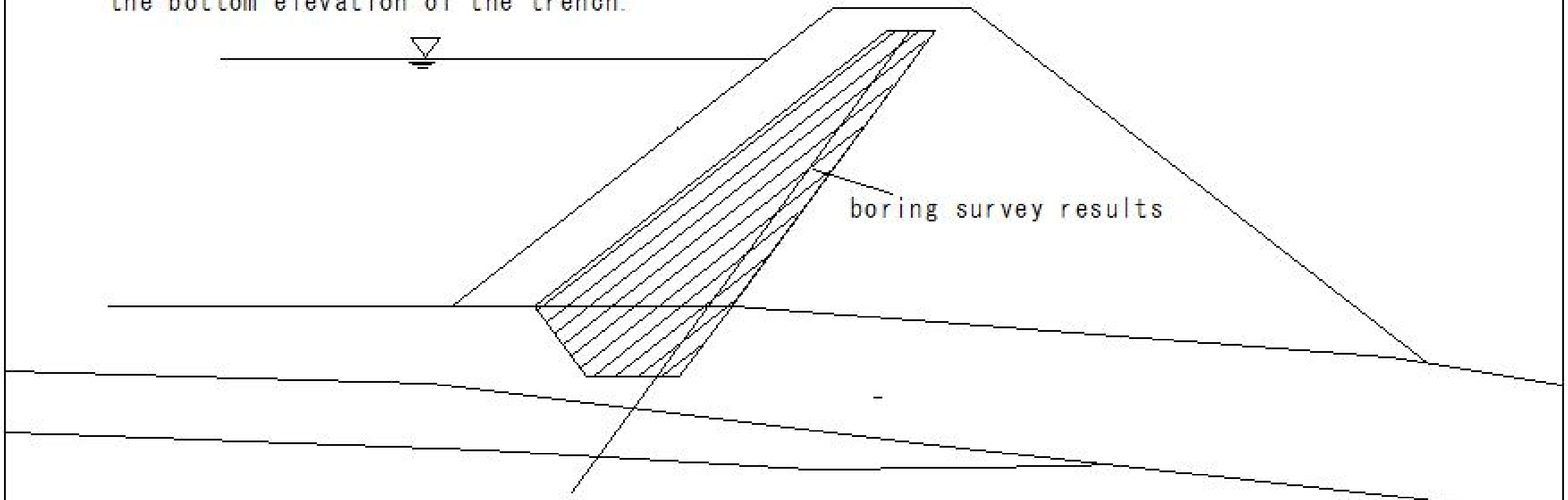
Embankment design concept (Geological map judgment: in-situ permeability coefficient of foundation ground)

① Immediately after embankment repair, the reservoir did not leak much and did not reach full water level.

② An oblique boring survey of the impermeable zone soil was carried out.

③ The strata and in-situ permeability coefficient of the embankment and foundation were confirmed.

④ A detailed examination of the boring survey results is required to determine the bottom elevation of the trench.



(I1581)Basic knowledge of reservoirs

(I1581) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

In case of repairing a reservoir, an appropriate investigation should be conducted to determine the necessity of repairing the reservoir based on the following points and to identify the causes of the reservoir's safety being compromised.

① Leakage from the entire reservoir

a. The leakage from the embankment at full water level exceeds 60?/min per 100m of embankment length.

b. The reservoir's original function of storing water has decreased, causing problems with water use.

c. The change in leakage when the water level is constant has increased by more than 10% in one month.

② Cracks and deformation of the embankment

③ Insufficient clearance of the embankment

④ Deformation of the cross-sectional shape of the embankment

⑤ High infiltration line position

⑥ Deterioration of spillway function and insufficient cross-section of water flow

⑦ Deterioration of intake facility function

⑧ Deterioration or deficiency of safety management facility function

(I1582)Basic knowledge of reservoirs

(I1582) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

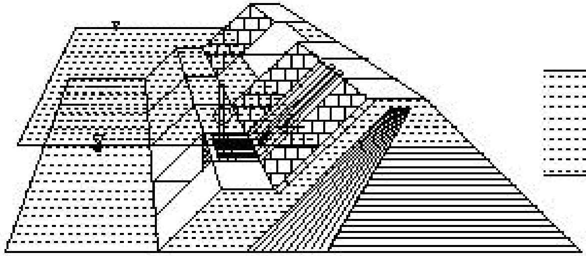
In case of repairing a reservoir, an appropriate investigation should be conducted to determine the necessity of repairing the reservoir based on the following points and to identify the causes of the reservoir's safety being compromised.

① Leakage from the entire reservoir

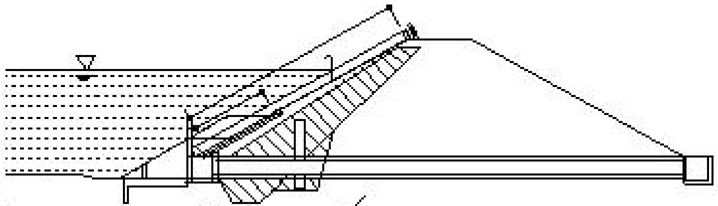
a. The leakage from the embankment at full water level exceeds 60?/min per 100m of embankment length.

b. The reservoir's original function of storing water has decreased, causing problems with water use.

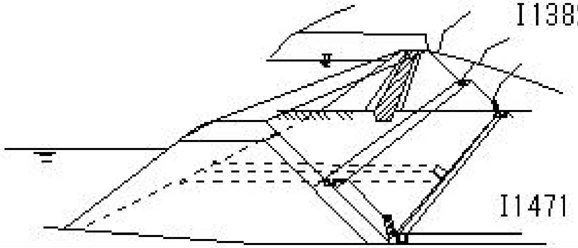
c. The change in leakage when the water level is constant has increased by more than 10% in one month.



I1382



I1392



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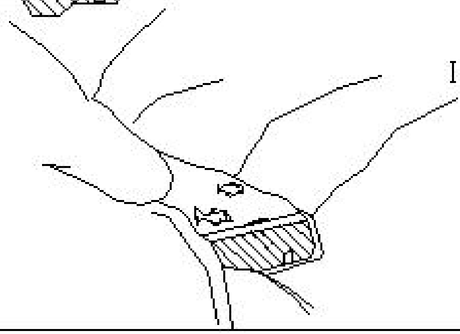


I1380

(I1583)Basic knowledge of reservoirs

(I1583) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

In case of repairing a reservoir, an appropriate investigation should be conducted to determine the necessity of repairing the reservoir based on the following points and to identify the causes of the reservoir's safety being compromised.

② Cracks and deformation of the embankment

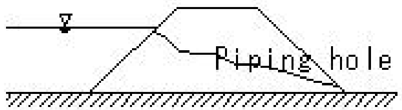
① Overflow destruction

I1487

② Slide failure

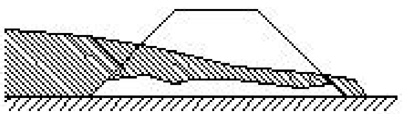
I1488

③ Seepage failure Seepage failure



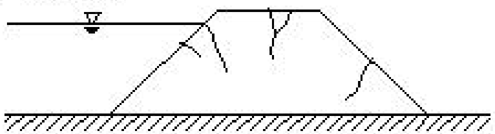
I1489

④ Collapse due to debris flow



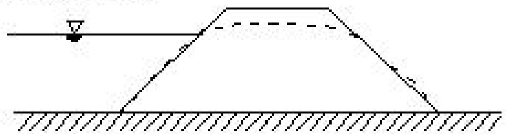
I1490

⑤ Cracks



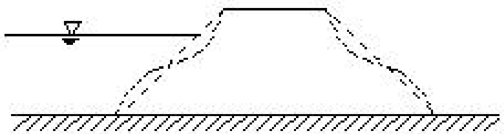
I1491

⑥Subsidence



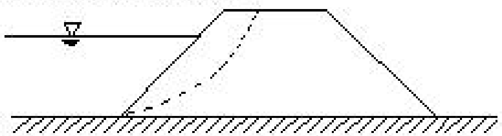
I1492

⑦ Slope collapse



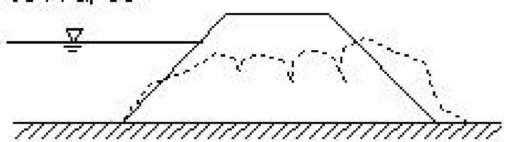
I1493

⑧Slope landslide



I1494

⑨Collapse



I1495

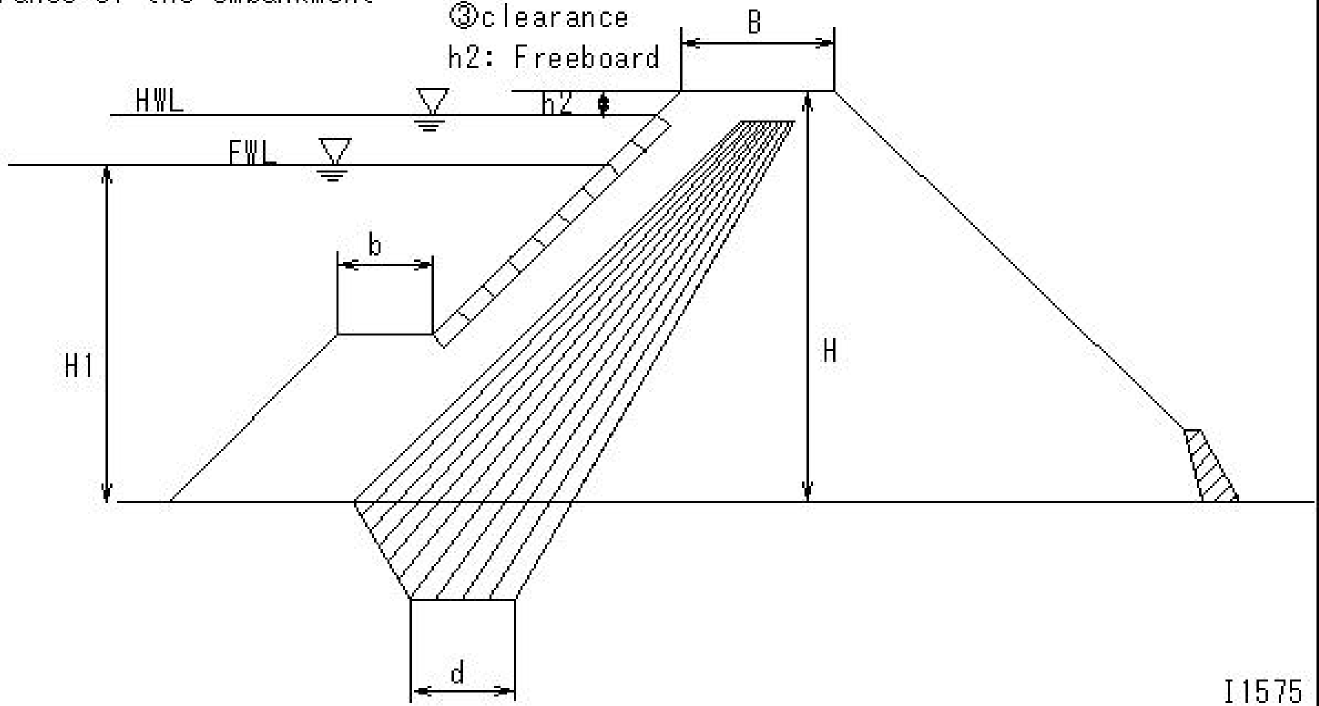
(I1584)Basic knowledge of reservoirs

(I1584) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

In case of repairing a reservoir, an appropriate investigation should be conducted to determine the necessity of repairing the reservoir based on the following points and to identify the causes of the reservoir's safety being compromised.

③ Insufficient clearance of the embankment



(I1585)Basic knowledge of reservoirs

(I1585) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

In case of repairing a reservoir, an appropriate investigation should be conducted to determine the necessity of repairing the reservoir based on the following points and to identify the causes of the reservoir's safety being compromised.

④ Deformation of the cross-sectional shape of the embankment

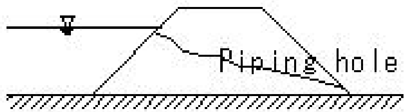
① Overflow destruction

I1487

② Slide failure

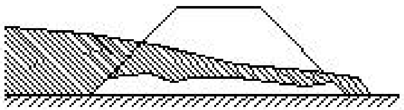
I1488

③ Seepage failure Seepage failure



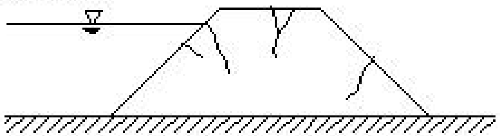
I1489

④ Collapse due to debris flow



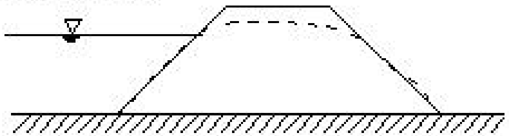
I1490

⑤ Cracks



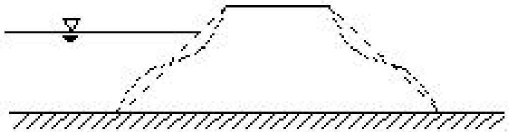
I1491

⑥Subsidence



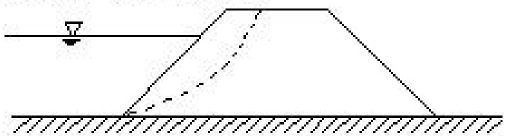
I1492

⑦ Slope collapse



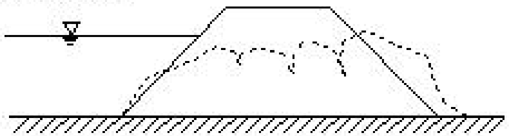
I1493

⑧Slope landslide



I1494

⑨Collapse



I1495

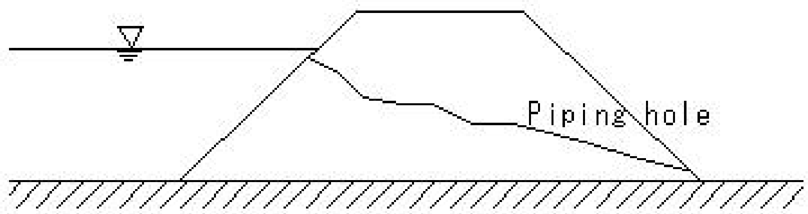
(I1586)Basic knowledge of reservoirs

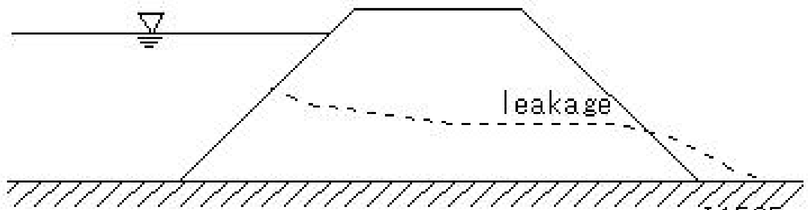
(I1586) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

In case of repairing a reservoir, an appropriate investigation should be conducted to determine the necessity of repairing the reservoir based on the following points and to identify the causes of the reservoir's safety being compromised.

⑤ High infiltration line position





I1505
I1491

I1489

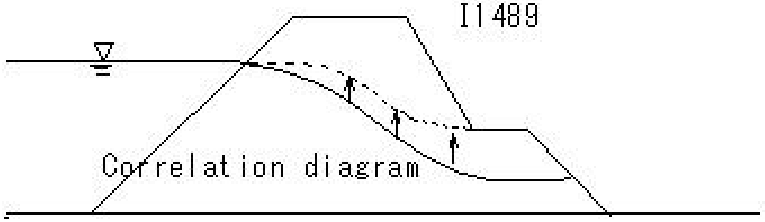


Figure Image of rising water level inside the dam

I1551

(I1587)Basic knowledge of reservoirs

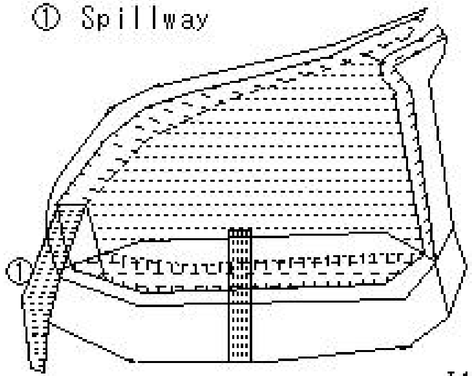
(I1587) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

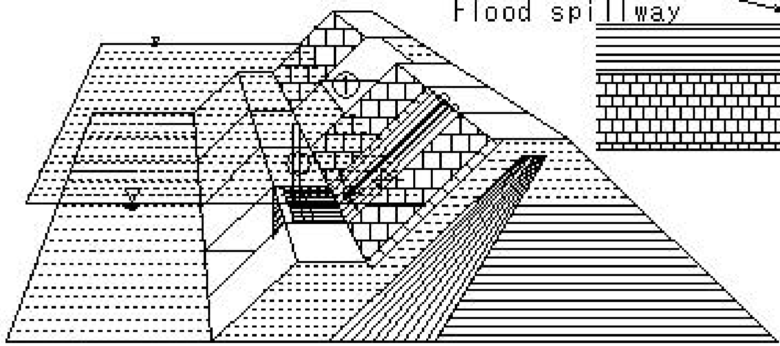
⑥ Deterioration of spillway function and insufficient cross-section of water flow

I1568

① Spillway



I1386



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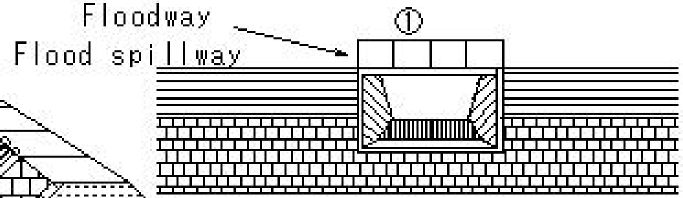

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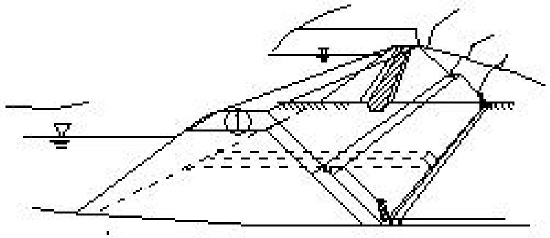
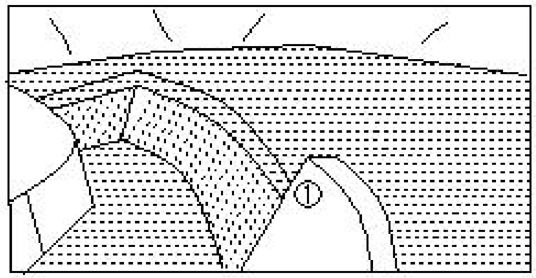


I1471

I1380



I1479

(I1588)Basic knowledge of reservoirs

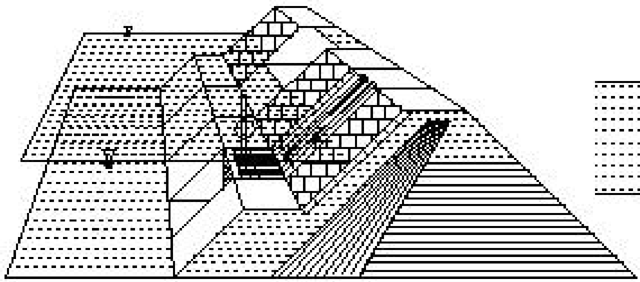
(I1588) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

In case of repairing a reservoir, an appropriate investigation should be conducted to determine the necessity of repairing the reservoir based on the following points and to identify the causes of the reservoir's safety being compromised.

⑦ Deterioration of intake facility function

I1566



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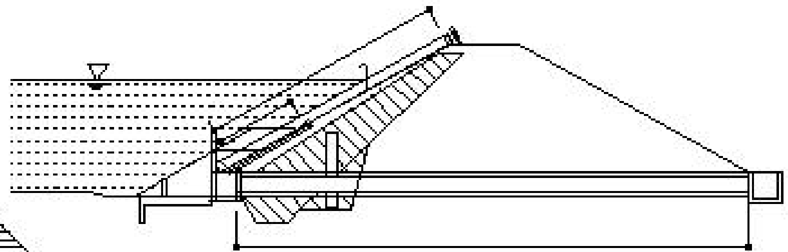
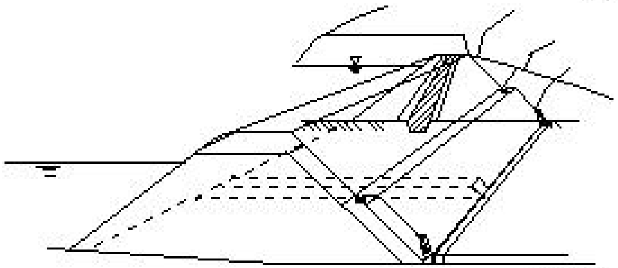


I1392



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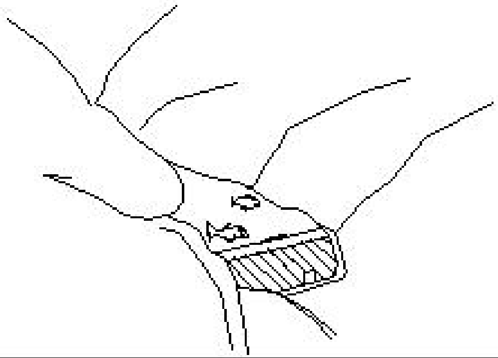


I1380

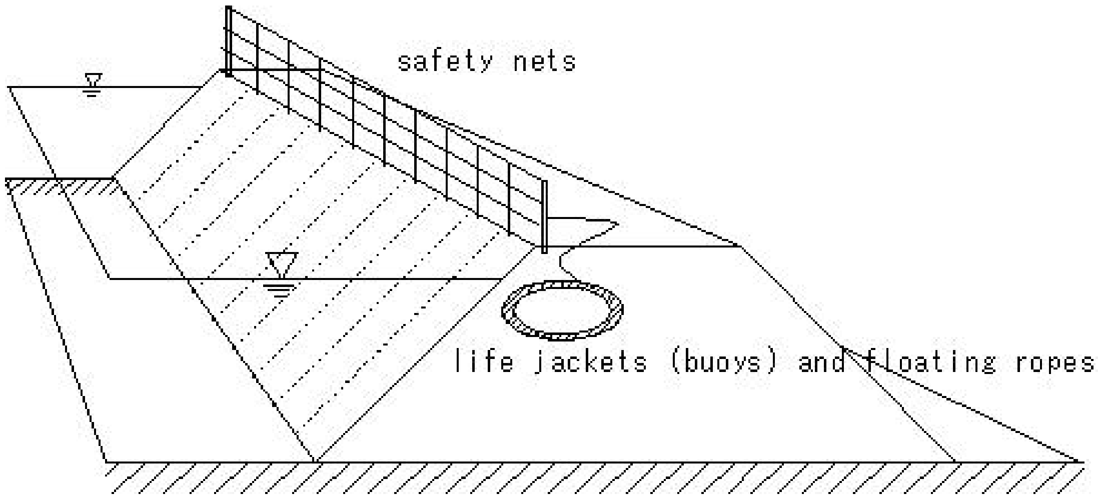
(I1589)Basic knowledge of reservoirs

(I1589) Basic knowledge of reservoirs

1. Embankment design concept (Embankment leakage concept)

In case of repairing a reservoir, an appropriate investigation should be conducted to determine the necessity of repairing the reservoir based on the following points and to identify the causes of the reservoir's safety being compromised.

⑧ Deterioration or deficiency of safety management facility function



I1520

(I1590)Basic knowledge of reservoirs

(I1590) Basic knowledge of reservoirs

Concepts for each facility (points to consider when designing each facility)

Points to consider

1. Case of leakage due to change in spillway position
2. Uneven settlement of spillway channel on embankment
3. Case of embankment sleeve entrapment
4. Case where pond bottom excavation reached gravel layer
5. Foundation treatment of spillway and bottom gutter connection
6. Case of uneven settlement
7. Case of tension block
8. Temporary road requiring ground improvement

(I1591)Basic knowledge of reservoirs

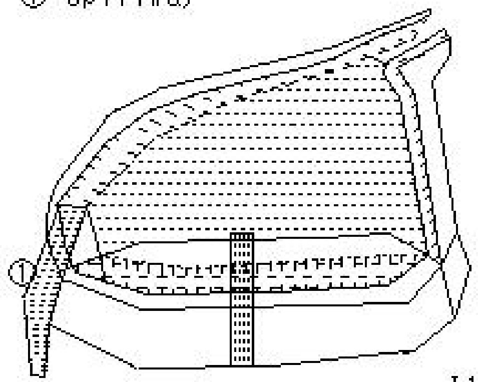
(I1591) Basic knowledge of reservoirs

Concepts for each facility (points to consider when designing each facility)

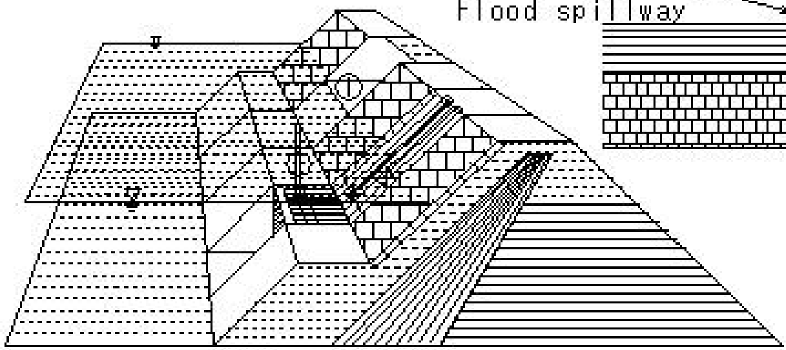
Points to consider

1. Case of leakage due to change in spillway position

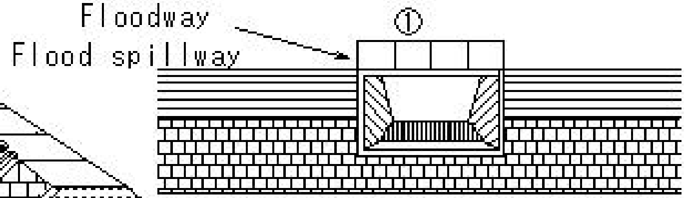
① Spillway



I1386



I1382



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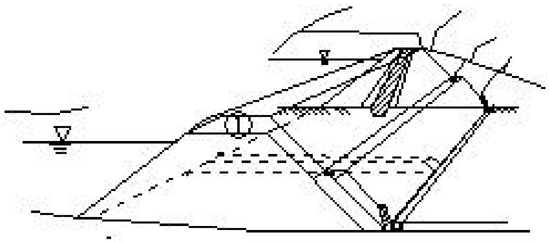

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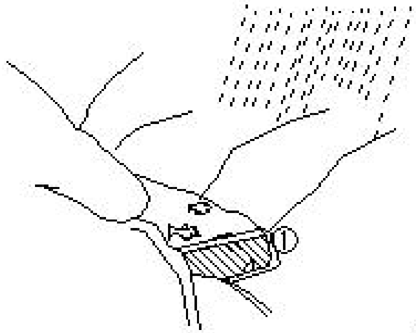
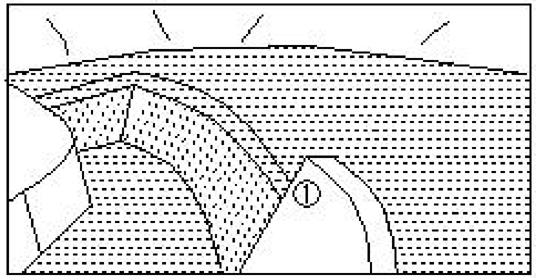
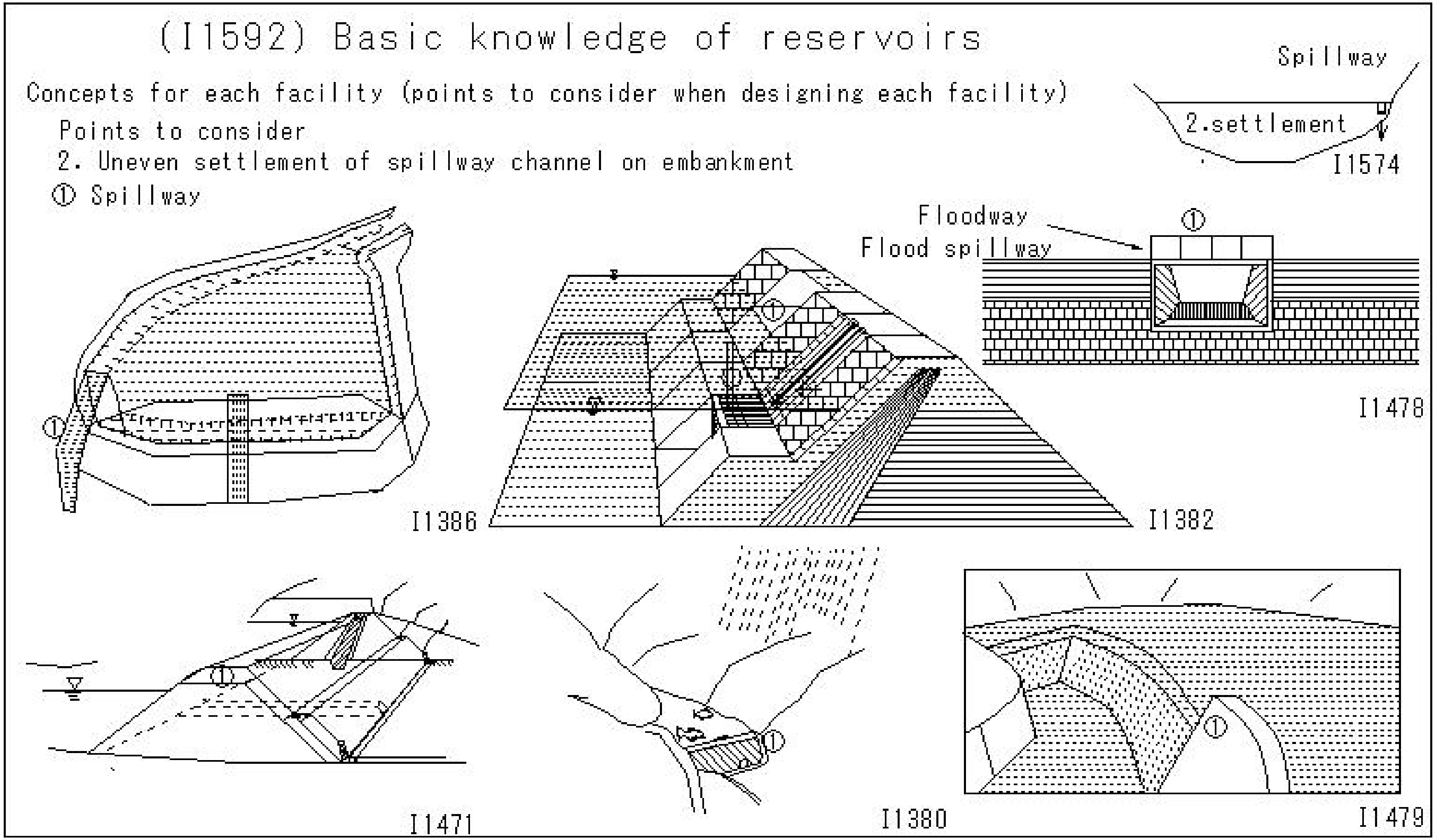


I1380

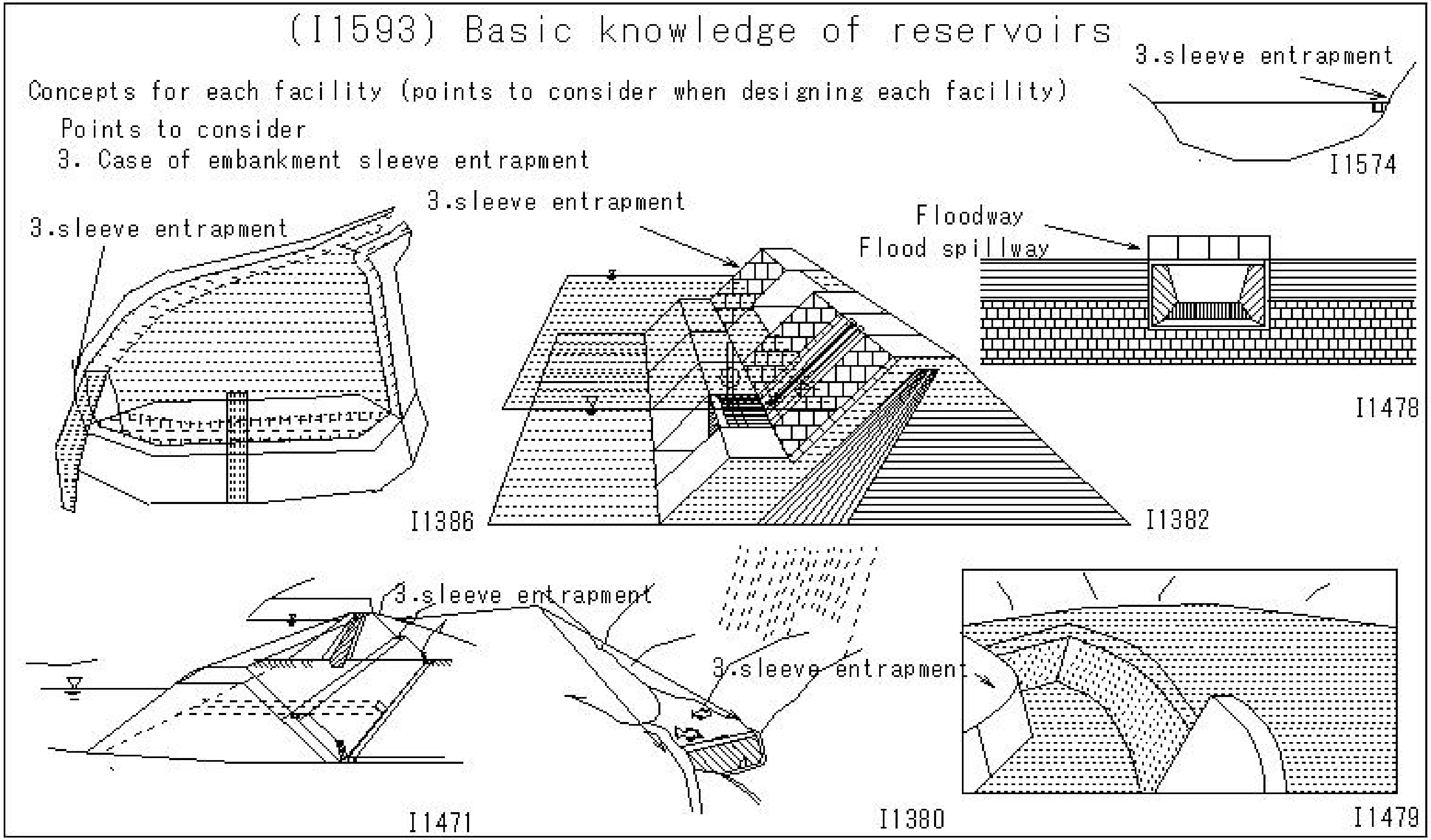


I1479

(I1592)Basic knowledge of reservoirs



(I1593)Basic knowledge of reservoirs



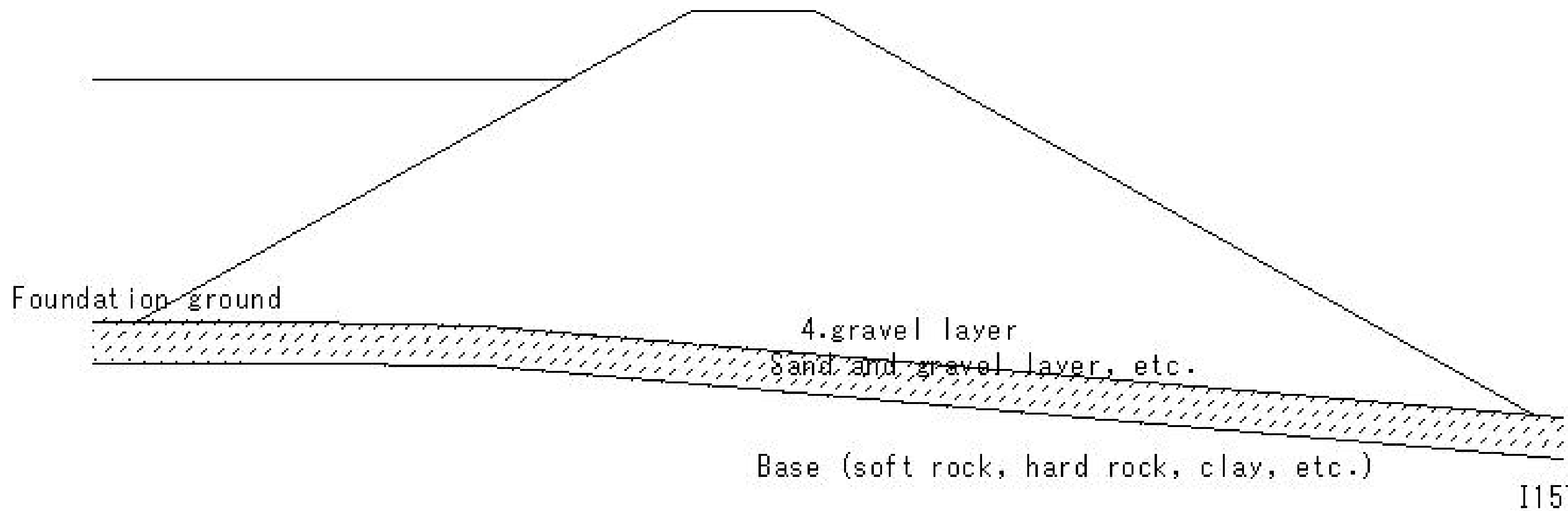
(I1594)Basic knowledge of reservoirs

(I1594) Basic knowledge of reservoirs

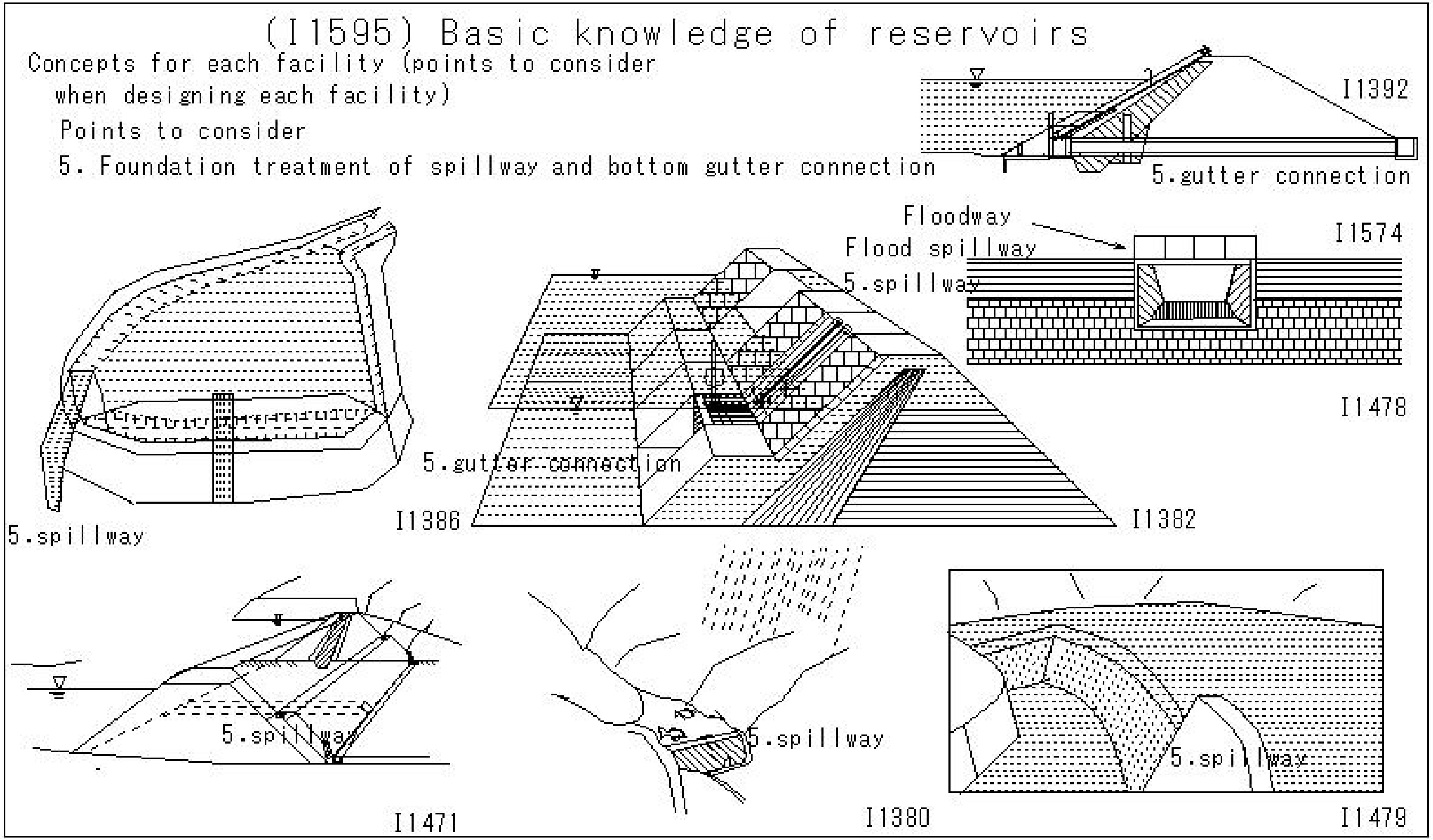
Concepts for each facility (points to consider when designing each facility)

Points to consider

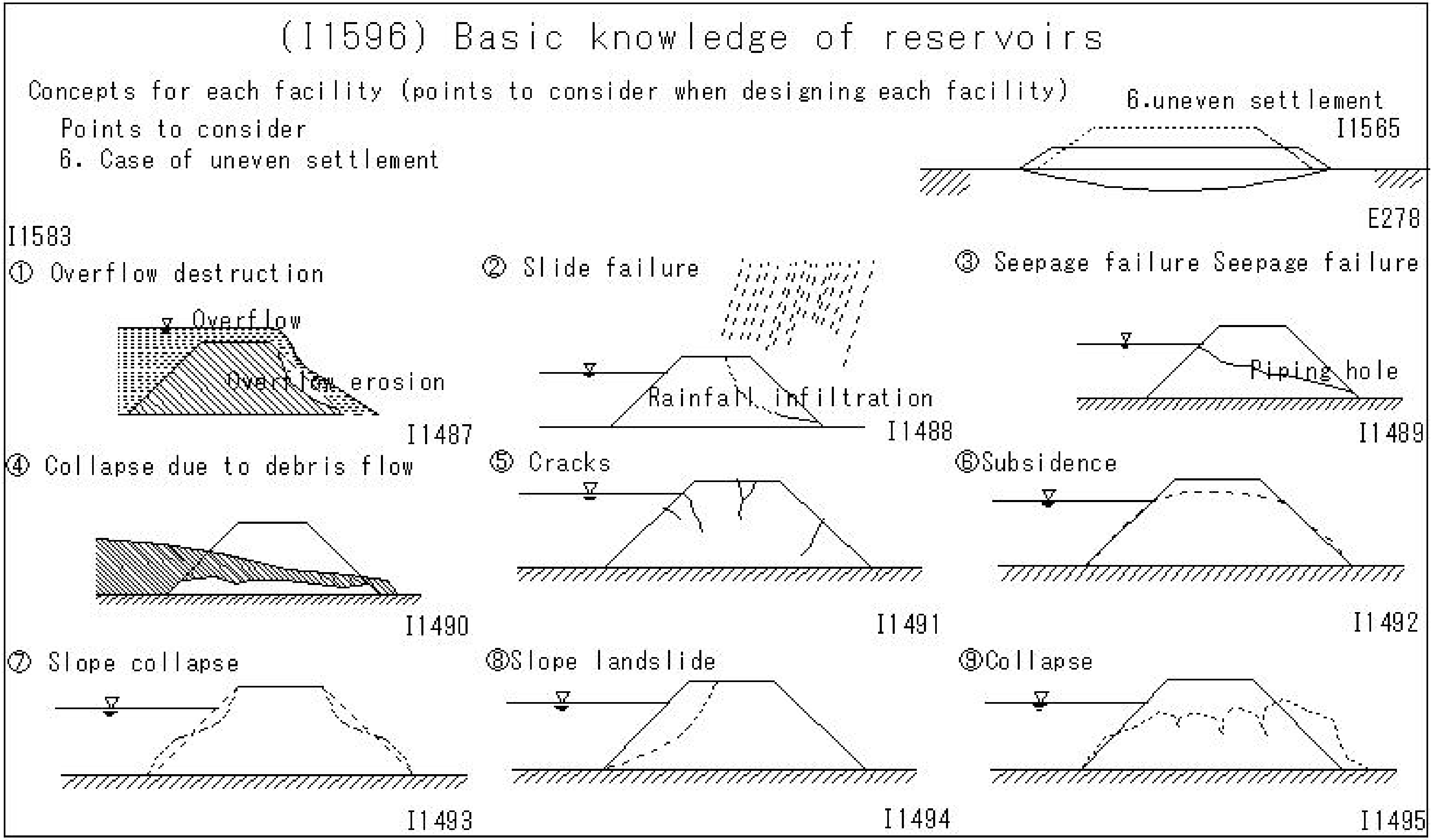
4. Case where pond bottom excavation reached gravel layer



(I1595)Basic knowledge of reservoirs



(I1596)Basic knowledge of reservoirs



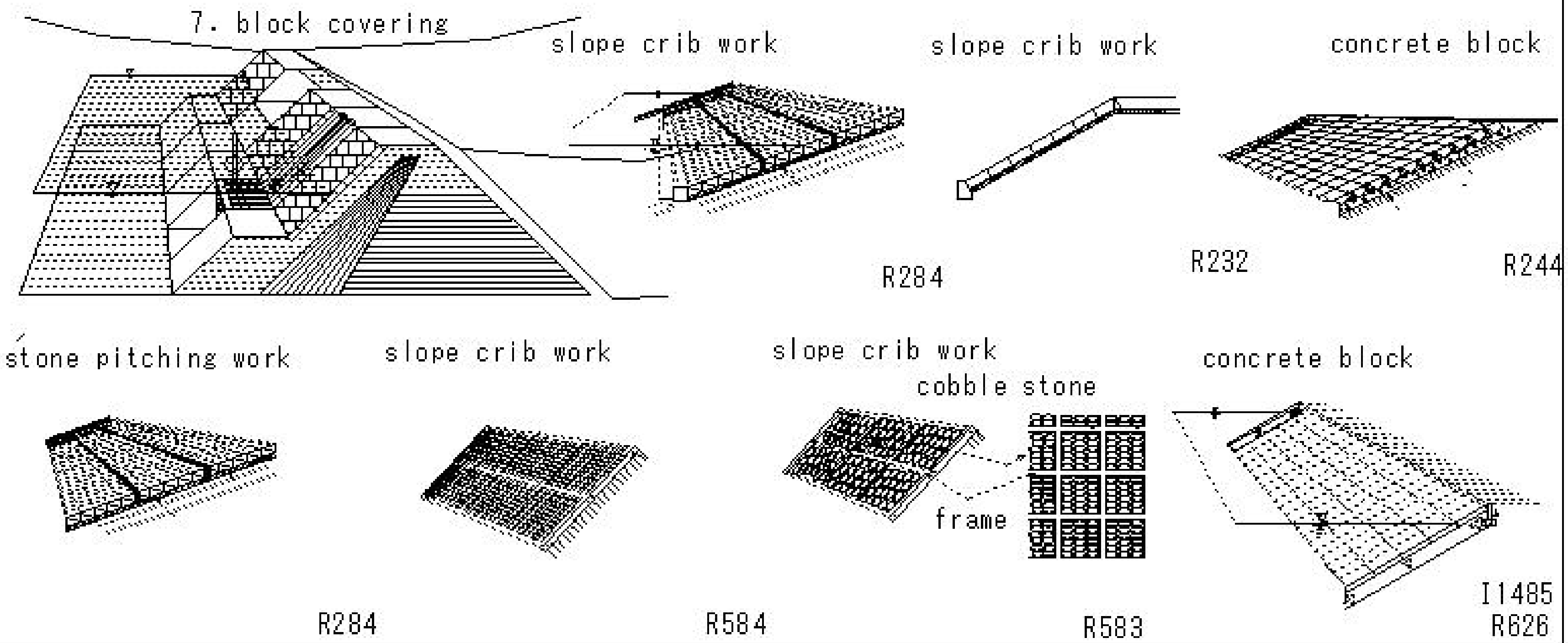
(I1597)Basic knowledge of reservoirs

(I1597) Basic knowledge of reservoirs

Concepts for each facility (points to consider when designing each facility)

Points to consider

7. Case of block covering



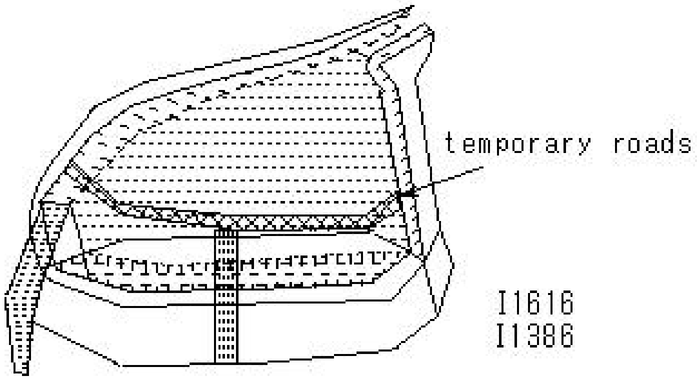
(I1598)Basic knowledge of reservoirs

(I1598) Basic knowledge of reservoirs

Concepts for each facility (points to consider when designing each facility)

Points to consider

8. Temporary road requiring ground improvement



I1616
I1386

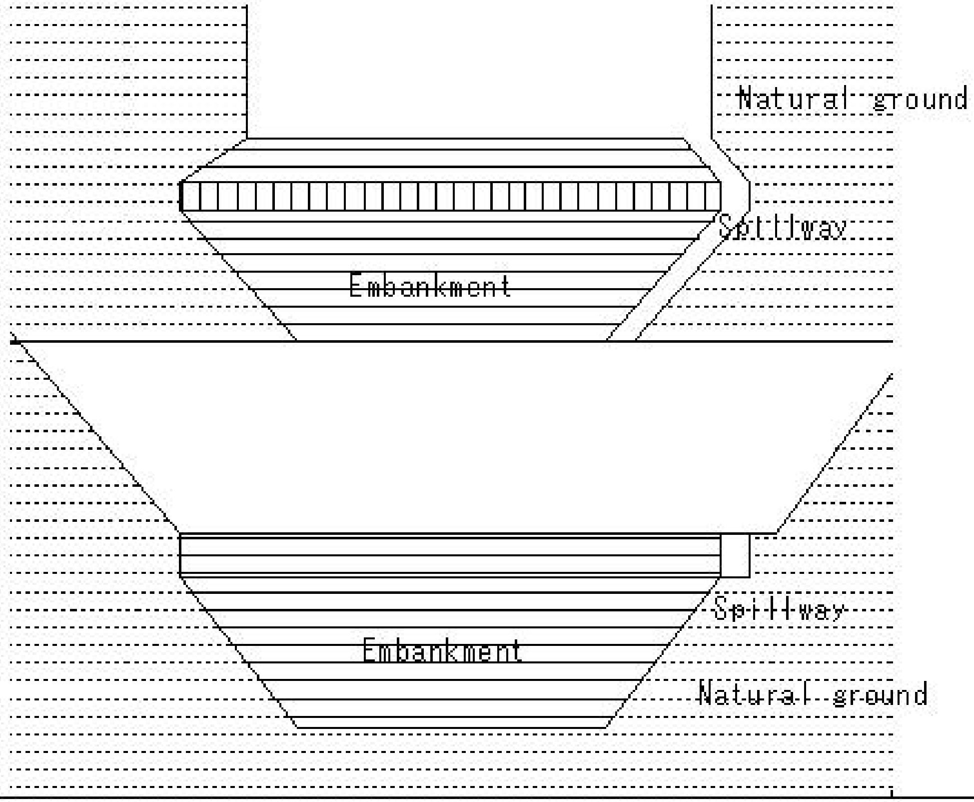
(I1599)Basic knowledge of reservoirs

(I1599) Basic knowledge of reservoirs

2. Concept of each facility (spillway location)

①Spillways are basically installed in the natural ground

②Measures are taken to prevent uneven settlement of structures and seepage flow



(I1600)Basic knowledge of reservoirs

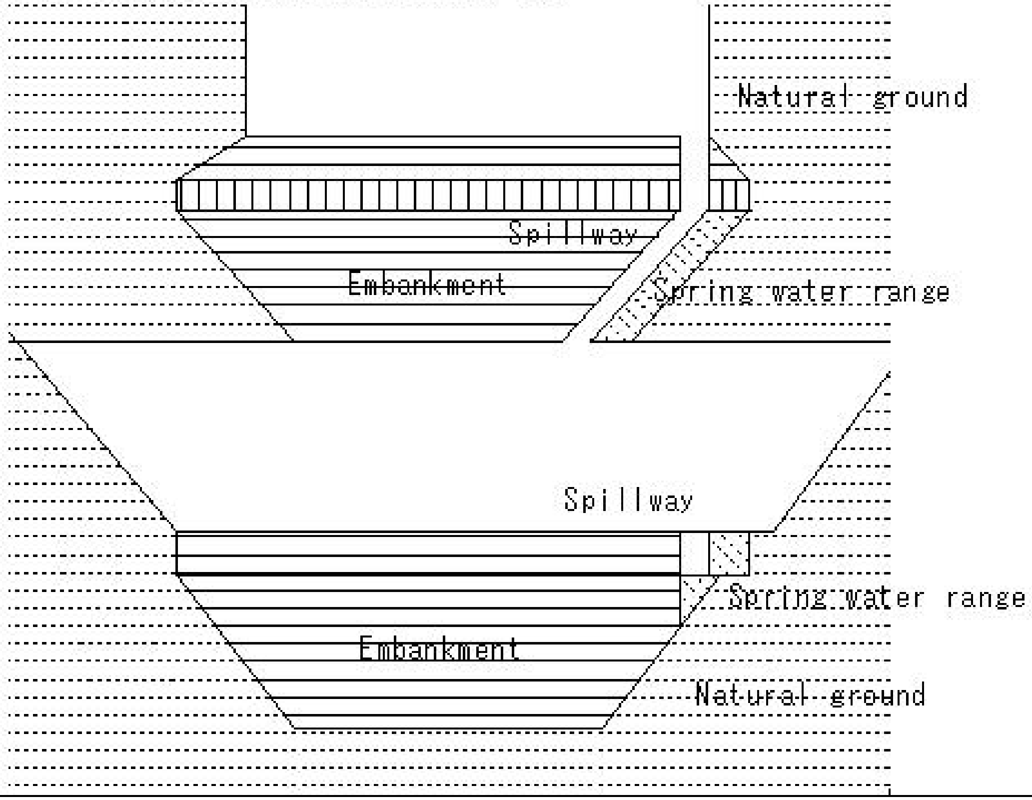
(I1600) Basic knowledge of reservoirs

(Leakage due to change in spillway position)

① In case of repairing a spillway, the previous spillway alignment should be the first priority

② In case of it is unavoidable to install it on the embankment

③ Sufficient foundation treatment must be carried out.



(I1601)Basic knowledge of reservoirs

(I1601) Basic knowledge of reservoirs

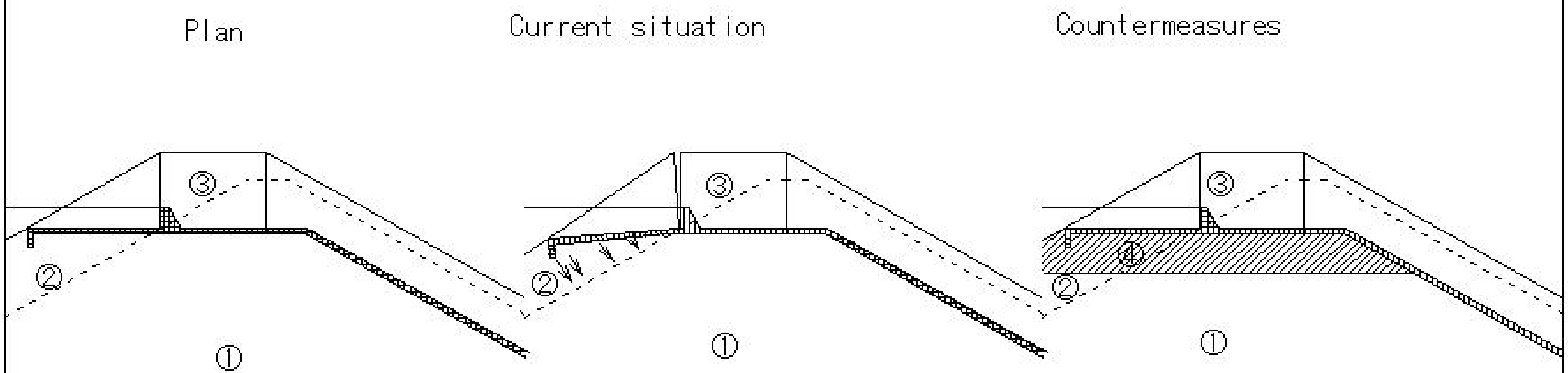
2. Concept of each facility (uneven settlement of flood spillway on embankment)

This is an example of a gap in the side wall of a flood spillway on embankment.

Countermeasures:

It is necessary to improve the foundation of the flood spillway about 1m deep (old embankment + embankment) with a cement-based solidifying agent to prevent uneven settlement of the structure.

①Old embankment
②Embankment
③Flood spillway
④Ground improvement



(I1602)Basic knowledge of reservoirs

(I1602) Basic knowledge of reservoirs

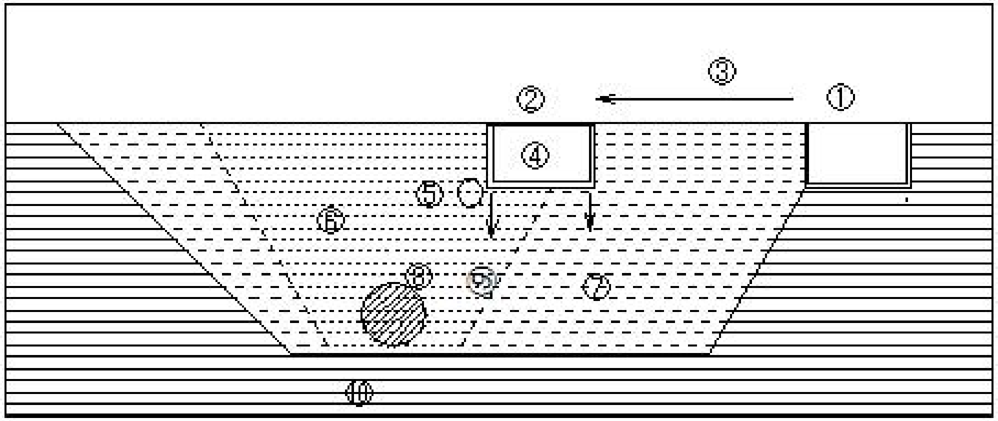
2. Concept of each facility (Uneven settlement of spillway on embankment)

This is a case where a spillway that was located in the natural ground of the embankment was moved to the embankment of the embankment.

○ The new spillway was planned at the boundary between the embankment and the natural ground, consolidation settlement occurred in the embankment, causing the spillway overflow to tilt.

○ ① New spillway
② Half of the structure was on the embankment
③ The structure settled unevenly immediately after installation
④ Piping occurred at the bottom of the channel, causing leakage
⑤ The side wall of the channel was excavated down to the foundation of the channel
⑥ Replaced with impermeable zone soil

○ ① Old spillway
② New spillway
③ Relocation
④ Uneven settlement
⑤ Leakage
⑥ Embankment
⑦ Embankment
⑧ Bottom gutter
⑨ Bottom gutter excavation line
⑩ Natural ground



(I1603)Basic knowledge of reservoirs

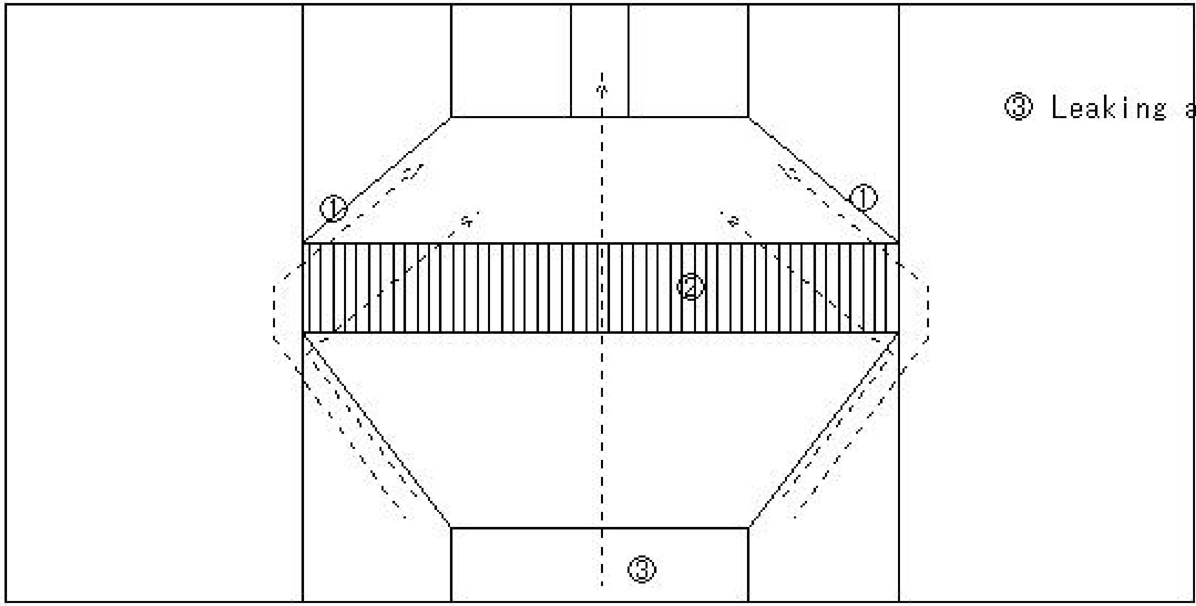
(I1603) Basic knowledge of reservoirs

2. Approach to each facility (example of embankment sleeve wrapping)

① In case of there is a permeable layer in the ground where the reservoir is located or in the bottom of the pond

② In case of there is leakage through the ground or the bottom of the pond.

③ In case of the embankment sleeve wrapping or the bottom of the pond needs to be dealt with by using a blanket



(I1604)Basic knowledge of reservoirs

(I1604) Basic knowledge of reservoirs

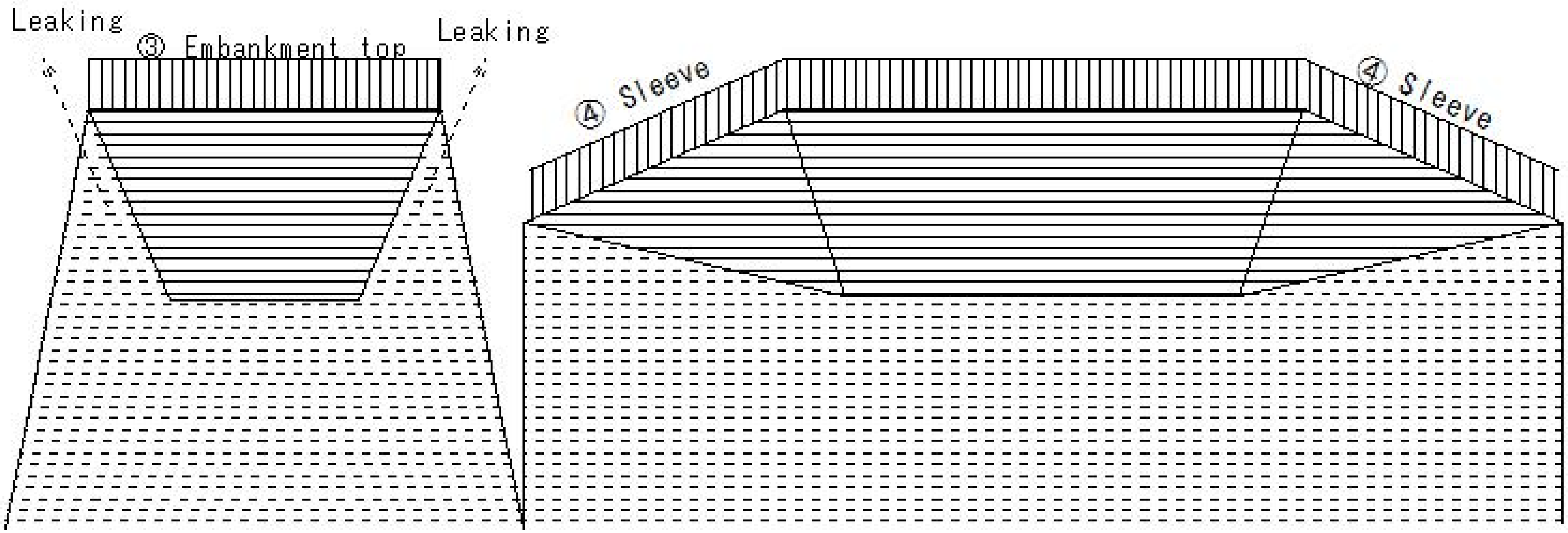
2. Concepts for each facility (examples of embankment sleeve wrapping)

① In case of the results of embankment boring indicate that there is leakage from the boundary between the embankment and the ground,

② Adding a sleeve to the current embankment ensures water stoppage.

③ There was leakage from the ground, so a sleeve was installed.

① Current plan　　　　② Planned plan



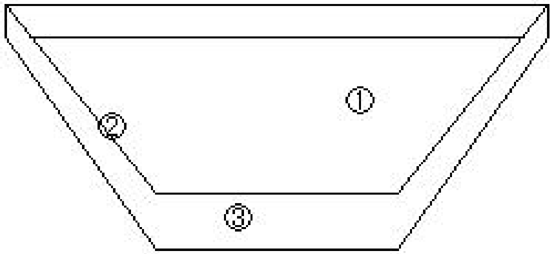
(I1605)Basic knowledge of reservoirs

(I1605) Basic knowledge of reservoirs

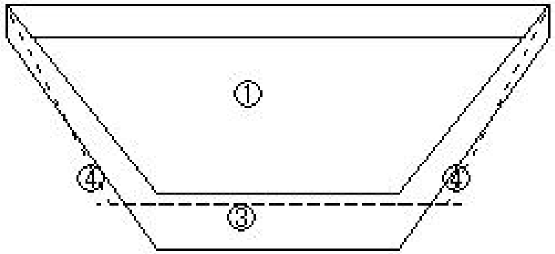
2. Approach to each facility (examples of embankment foundation and sleeve wrapping)

① Leakage is common after reservoir renovation
② Trench does not penetrate deep enough into the ground
③ In case of there are few boring points, it is difficult to judge at the design stage
④ It is important to check the foundation ground during construction

Planning stage



After construction



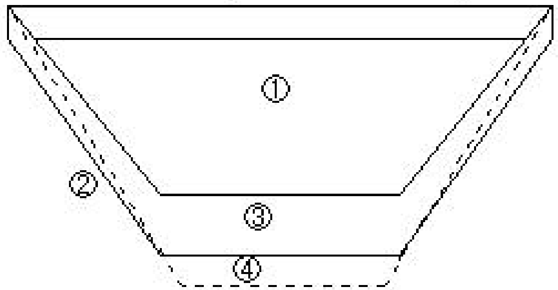
In case of the foundation ground in the ground is deep

① Embankment

② Foundation ground

③ Trench

④ Leakage area



In case of the foundation ground at the bottom of the pond is deep

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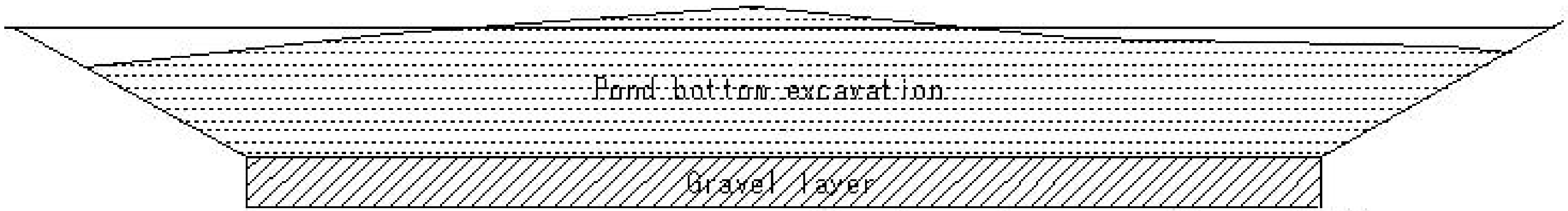
2 Concepts of each facility (A case where the pond bottom excavation reached the gravel layer)

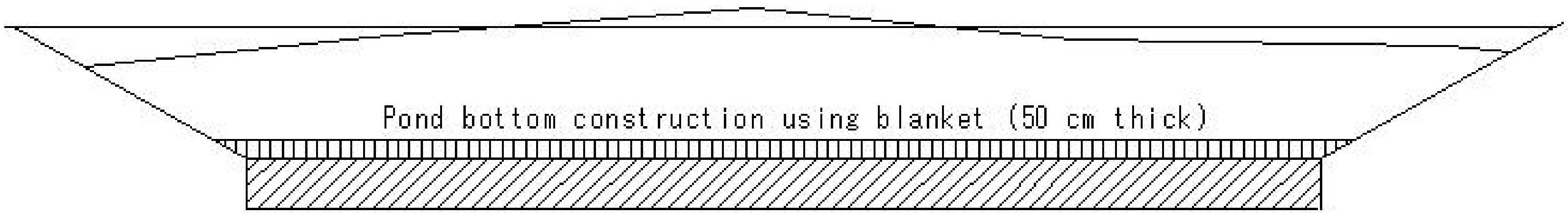
The planned water storage volume was secured by excavating the pond bottom, but there was a gravel layer at the bottom of the pond, and water leakage prevented the pond from reaching full capacity.

Cross-section of the reservoir



Gravel can be seen on the pond bottom

Pond bottom repair plan



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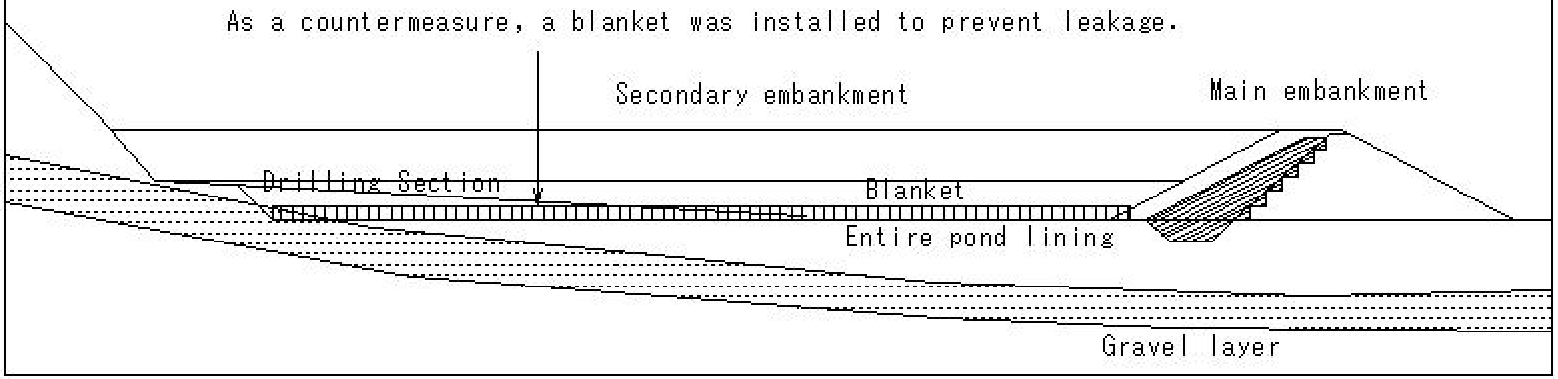
2. Concepts of each facility (example where pond bottom excavation reached the gravel layer)

In case of digging the bottom of a reservoir in mountainous areas, care must be taken as it may reach the gravel layer at the bottom.



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2. Concept of each facility (foundation treatment of Sediment discharge and bottom gutter connection)

① Crack at connection between Sediment discharge and bottom gutter

② Crack confirmed 10 years after construction

③ Improvement of Sediment discharge foundation is insufficient

④ Partial pipe rehabilitation and backfilling with impermeable zone soil

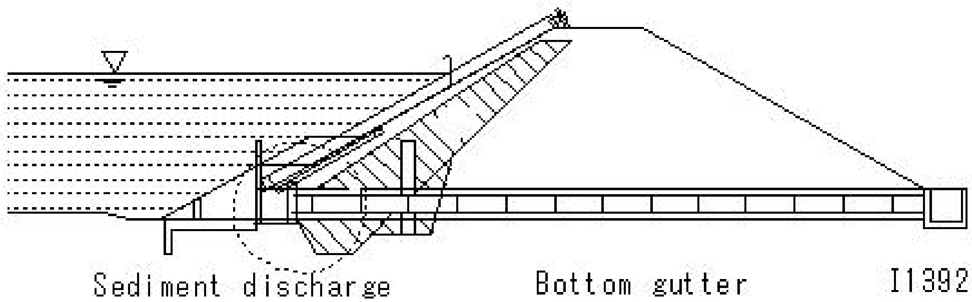
Piping of embankment

Crack at connection between Sediment discharge and bottom gutter

Leakage from crack

Backfilling of embankment with impermeable zone soil

Partial pipe rehabilitation



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2. Concept of each facility (foundation treatment of sand dump & bottom gutter connection)

① The Sediment discharge, which is a heavy structure, should be installed on a good foundation

② The result of installing the Sediment discharge in a 4m deep trench

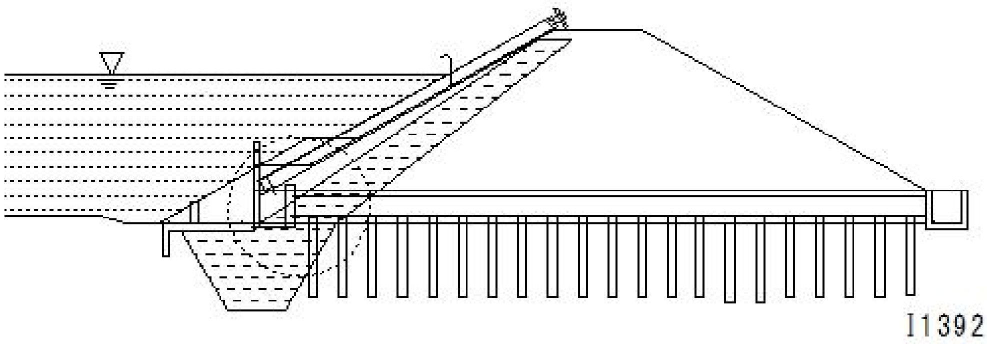
③ The Sediment discharge sank due to compaction of clayey soil in the trench

④ The bottom gutter did not sink due to the installation of pine piles

⑤ This is a case where the connection between the Sediment discharge and the bottom gutter was damaged about 10 years after construction

⑥ Subsidence of the Sediment discharge is possible

⑦ We will determine whether the Sediment discharge and the diagonal gutter need to be renovated.



Sediment discharge Bottom gutter

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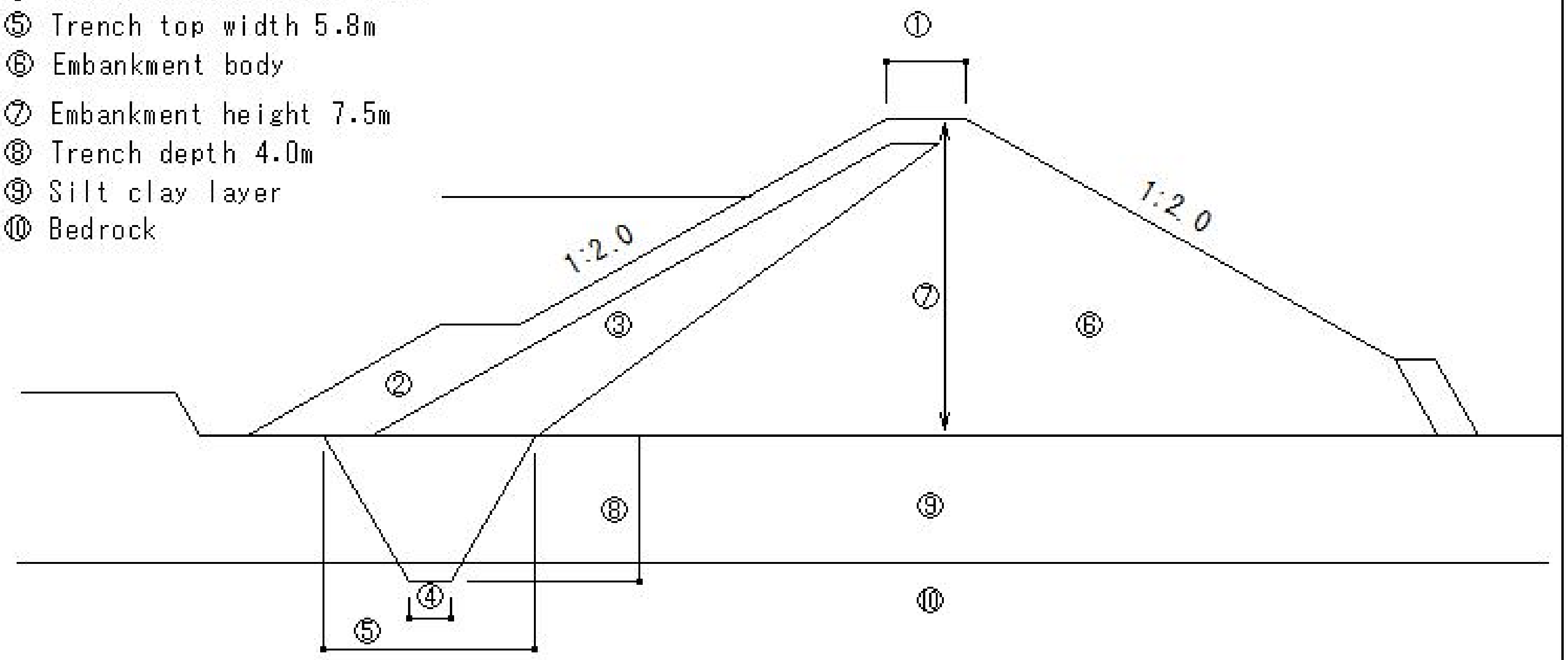
2. Concept of each facility (foundation treatment of sand dump & bottom gutter connection)

① Embankment width 3.5m
② Random materials
③ impermeable zone soil
④ Trench bottom width 1.8m
⑤ Trench top width 5.8m
⑥ Embankment body
⑦ Embankment height 7.5m
⑧ Trench depth 4.0m
⑨ Silt clay layer
⑩ Bedrock



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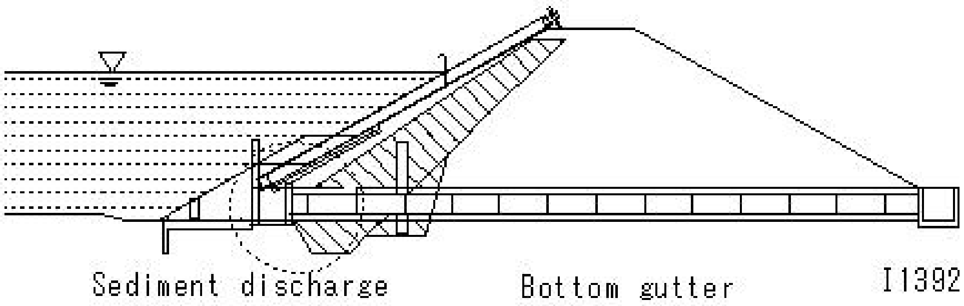
2. Concepts for each facility (foundation treatment of Sediment discharge and bottom culvert connection)
   1. Foundation treatment by mid-layer ground improvement
   2. Renovation of Sediment discharge and diagonal culvert



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2. Approaches to each facility (example of uneven settlement in the bottom sump)

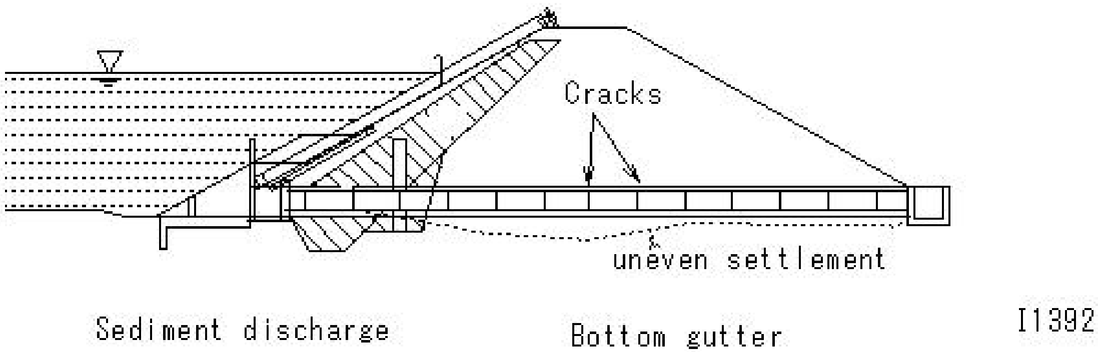
Cracks occurred in the joint

Countermeasures

① Change position to better ground

② Uniform improvement of foundation ground

③ Installation of (receiving platform)



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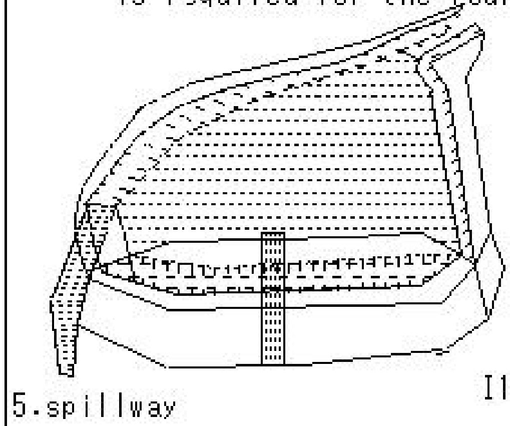
2. Approach to each facility (examples of differential settlement occurring at spillways, etc.)

   1) In embankments, structures settle differentially due to consolidation of clayey soil.

   2) In case of constructing a structure on embankments, ground improvement work is required for the foundations.



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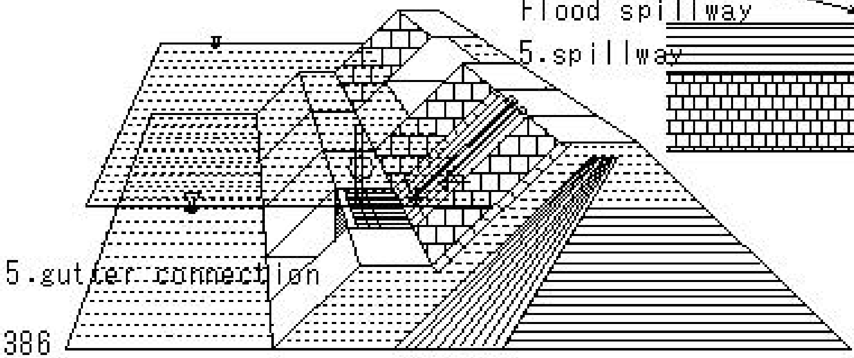

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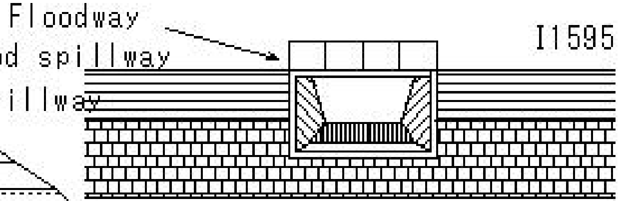

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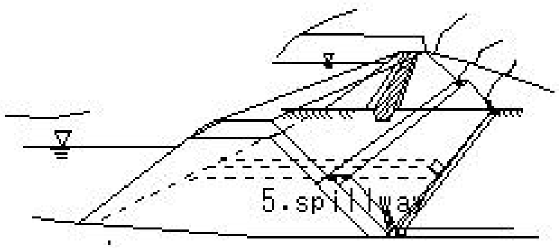

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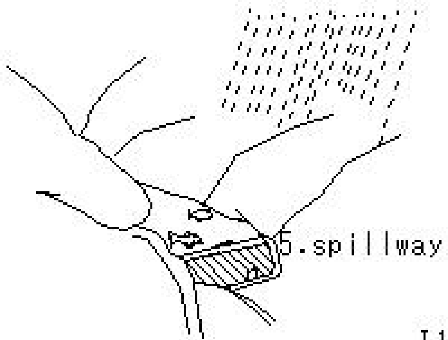

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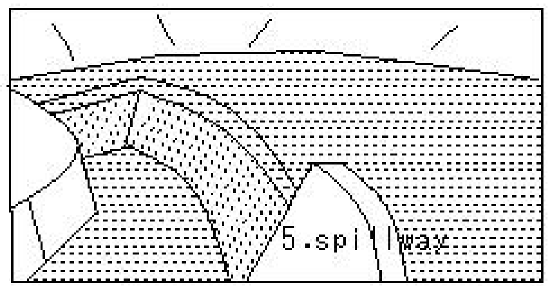

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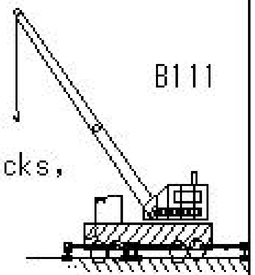
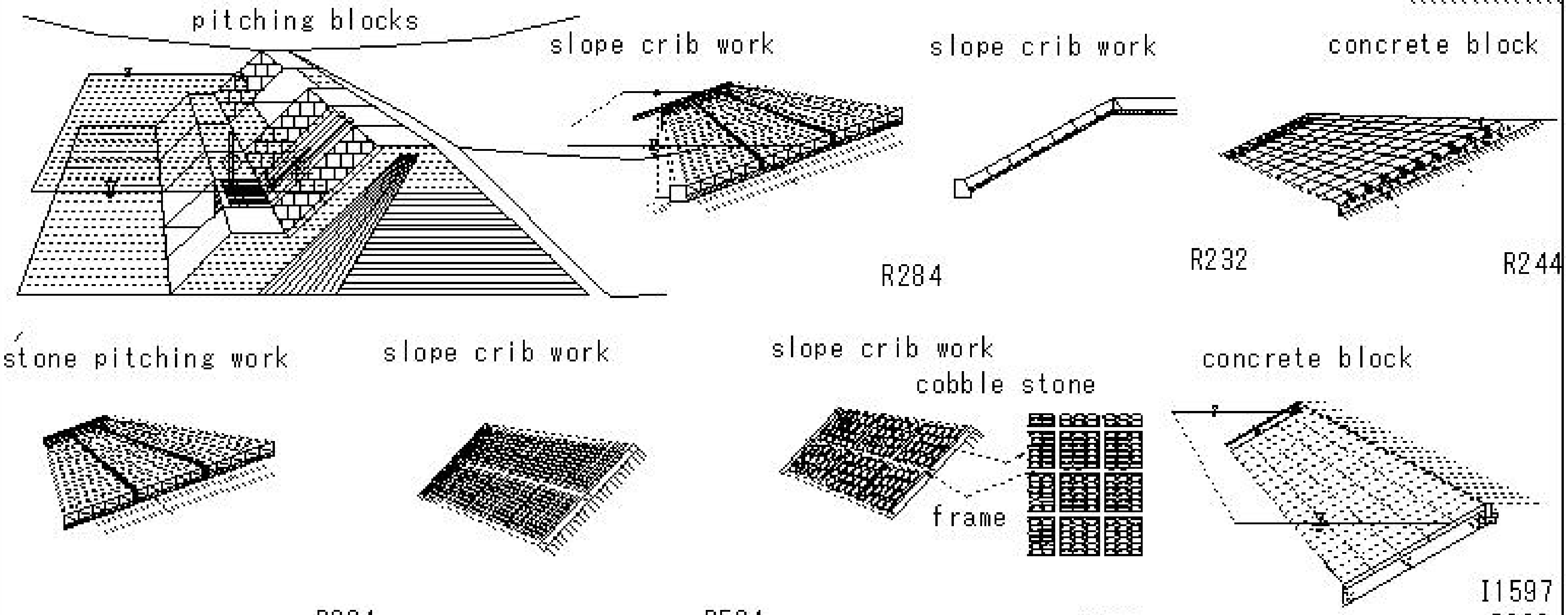
2. Concepts for each facility (Examples of pitching blocks)

① In recent years, large blocks have become cheaper and are increasingly being used.
② The condition is that the pond must be accessible to a crane truck to lift the blocks,
③ It is inexpensive and leads to shorter construction times.





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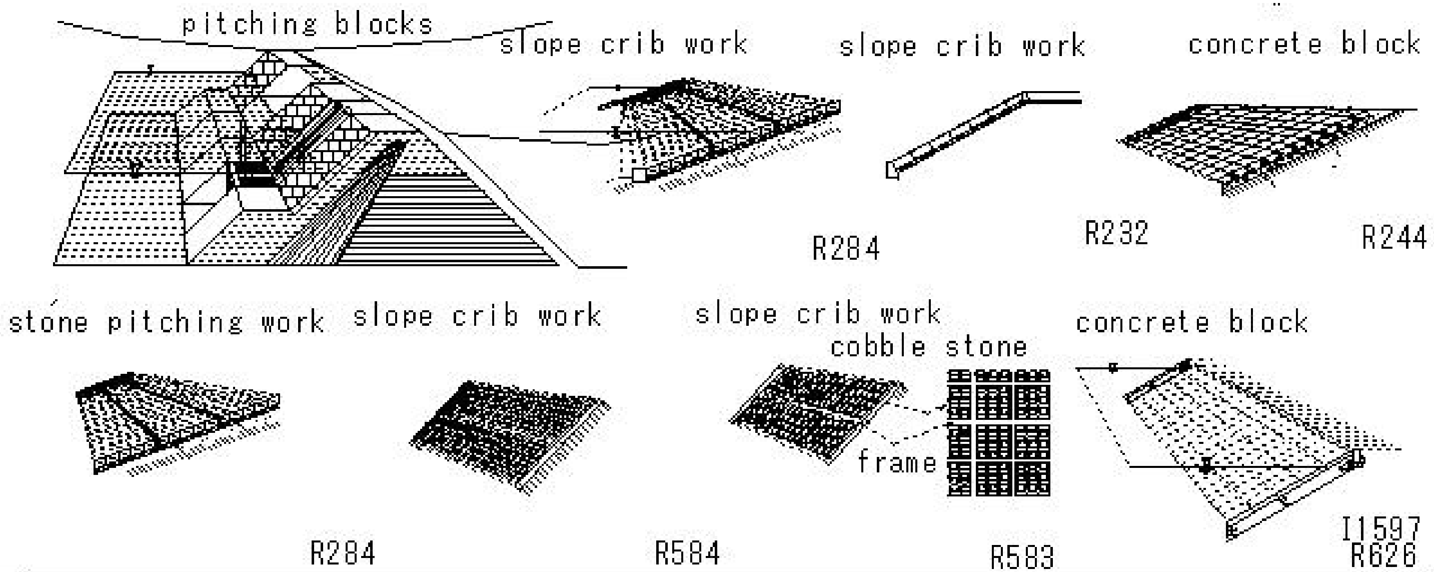
2. Concepts for each facility (Example of pitching blocks: Disaster prevention pitching blocks)

- Can be used for bank construction of reservoirs, rivers, creeks, and floodplains.
- Finely spaced vertical joints on the surface of the block provide excellent surface drainage, preventing the accumulation of dust, soil, and sand.
- The front of the surface is stepped, providing footholds for improved workability and safety.
- Finely spaced unevenness on the surface provides handholds in case of falls or slips.
- Large pitching blocks reduce construction costs, save labor by using machines, and shorten construction times.



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2. Concept of each facility (temporary roads requiring ground improvement)

Issues

① Time-consuming

② Preliminary design

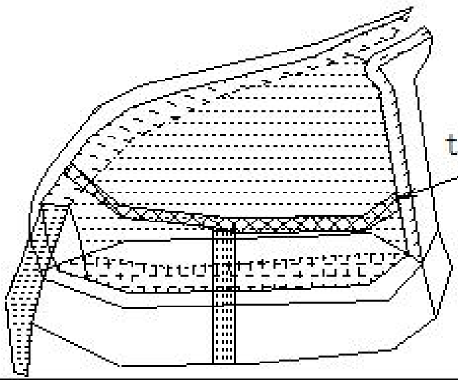
③ Inconsistency in the amount of improvement material

Proposal

① Re-examination of the process When planning the overall process for the reservoir construction, consider the actual improvement process and create a flexible schedule by referring to other cases in the area.

② Additional soil survey Conduct a soil survey at the planned site for detailed design of the temporary road

③ Additional on-site mix test Mix test of cement-based improvement material



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(I1617)Basic knowledge of reservoirs

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3. Points to note in construction supervision (when the impermeable zone soil and step are separated)

① The impermeable zone soil and step are constructed as one with the same material (impermeable zone soil).

② In case of the construction width is extremely narrow in the embankment downstream (colored part), careful attention must be paid to the compaction machine and soil type (clay soil).

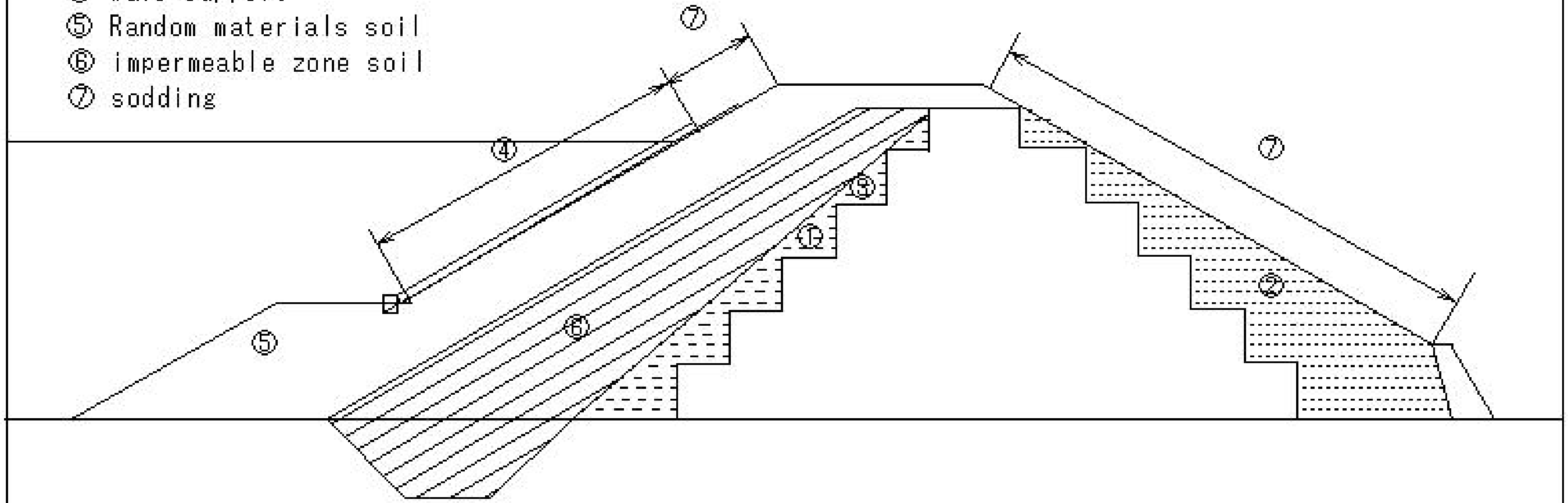
③ In case of the impermeable zone soil and step are separated, the area between them (colored part) must also be constructed with impermeable zone soil

④ Wave support

⑤ Random materials soil

⑥ impermeable zone soil

⑦ sodding



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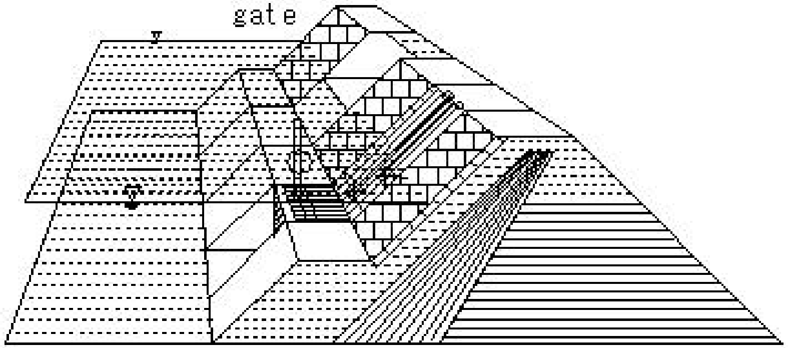
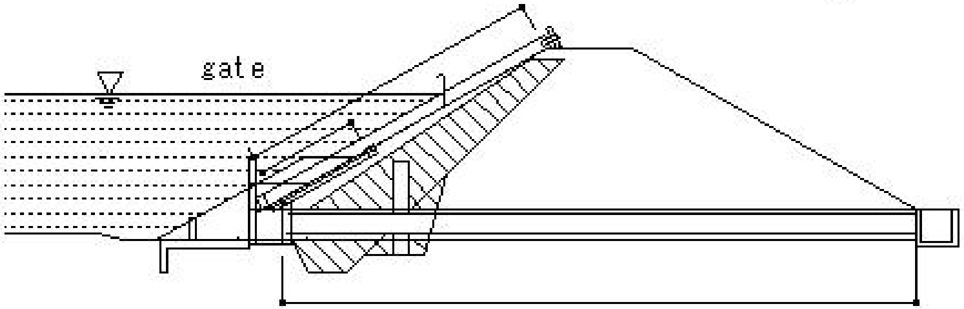
3. Points to note in construction supervision (in the case of gate installation)

Installation of a gate requires simultaneous construction of the structure and removal of boxes.





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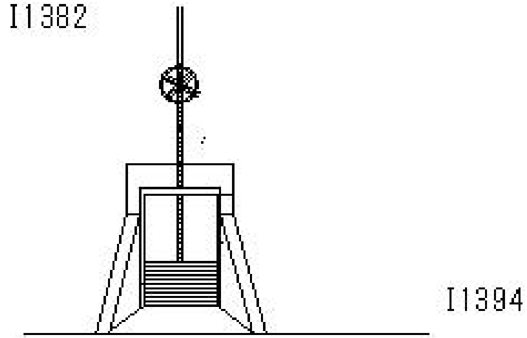

Sediment discharge gate

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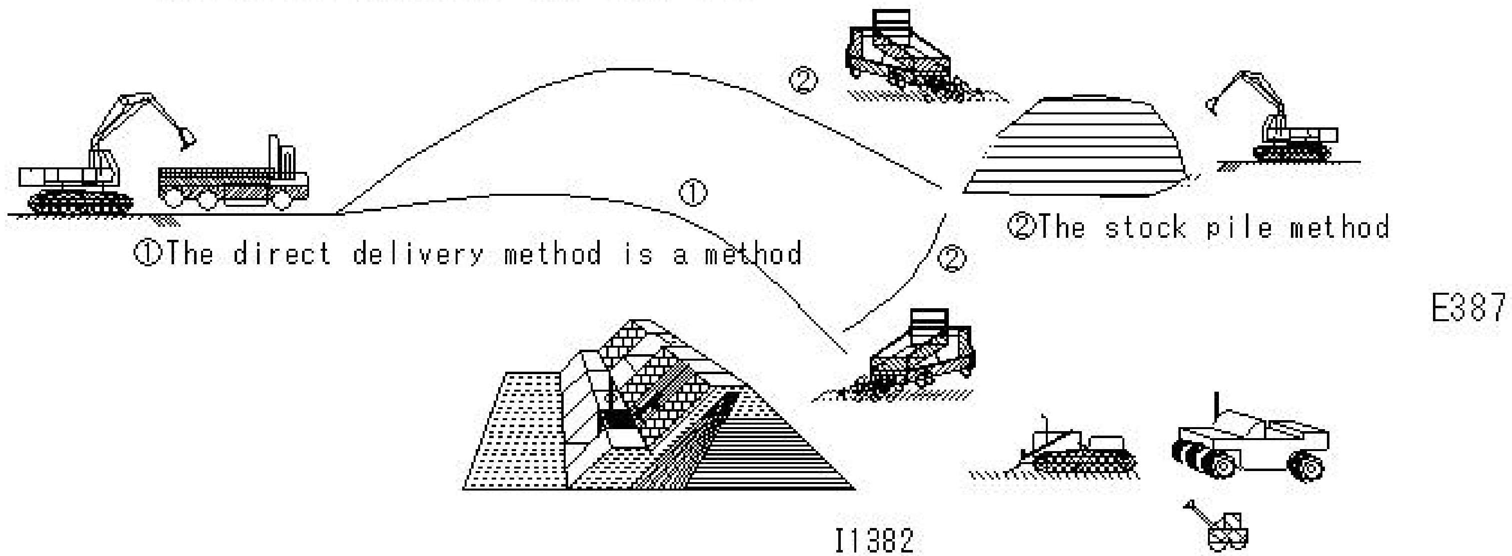
3. Points to consider in construction supervision (stock pile)

This is one of the methods for transporting materials for the dam body to the construction site when constructing a fill dam.

① The direct delivery method is a method in which soil and rocks collected from a borrow pit or raw stone mine are transported directly to the dam,

② The stock pile method is a method in which the soil and rocks are temporarily stored in another location, various processing and adjustments are performed, and then the rocks are transported to the dam from there.



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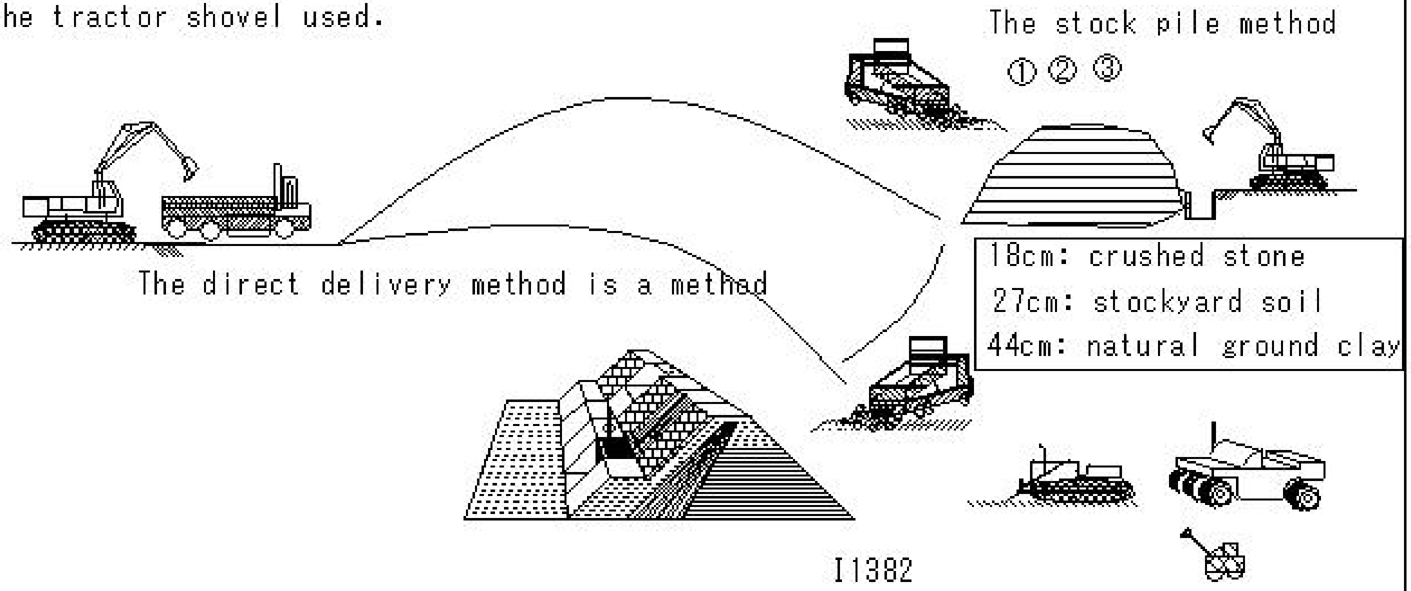
3. Points to consider in construction supervision (stock pile)

This is one of the methods for transporting materials for the dam body to the construction site when constructing a fill dam.

① The layer thickness should be as thin as possible, with the minimum thickness that the fine-grained material can be evenly spread.

② The pile base and soil surface should be sloped to allow for drainage.

③ The pile height should be 3-5m, which is the efficient excavation height for the tractor shovel used.

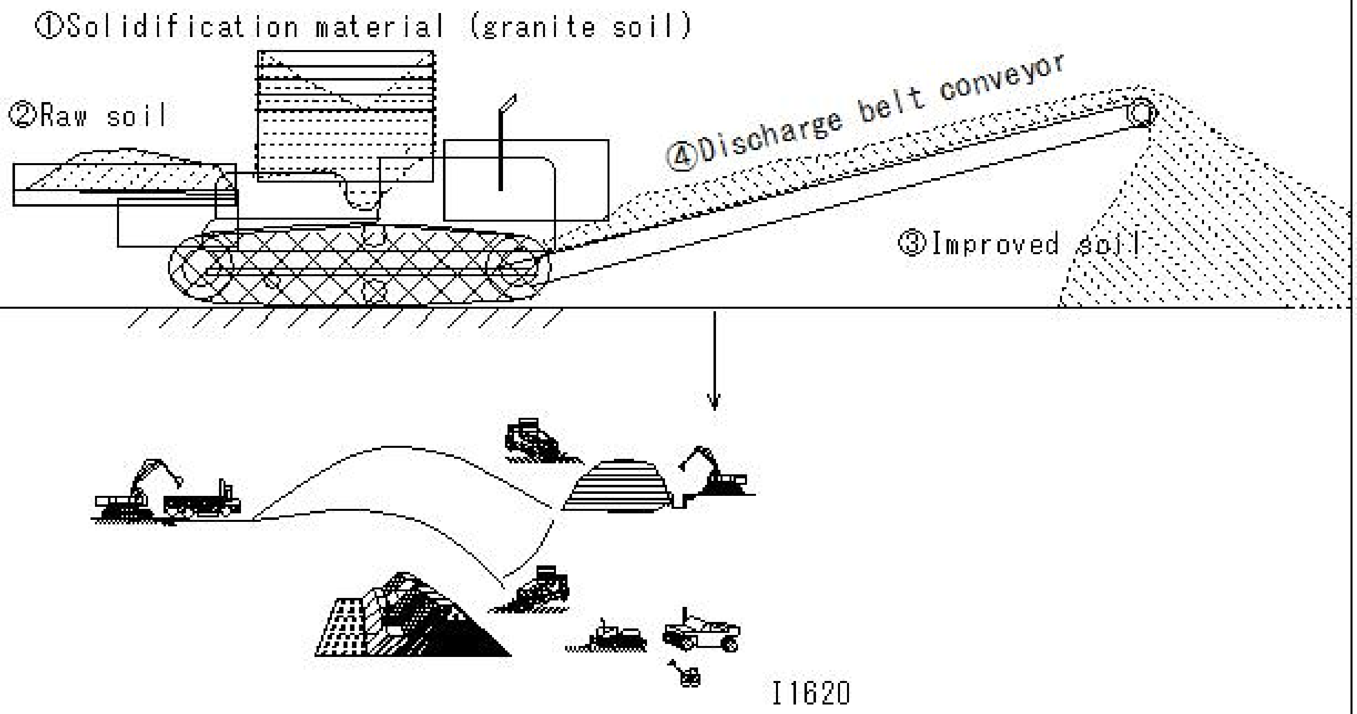


(I1621)Basic knowledge of reservoirs

(I1621) Basic knowledge of reservoirs

3. Points to note in construction supervision (clay soil mixing machine)

In case of mixing clay soil with quicklime or granite, uneven mixing is likely to occur.
Mechanical mixing is also an effective method for achieving uniform mixing.



(I1622) Reservoir Development

(I1622) Reservoir Development

1.2 Applicable to the renovation of reservoirs with a height of less than 15m

④ Ensuring continuity between reservoirs and the hinterland

⑤ Environmentally-conscious construction method for embankment

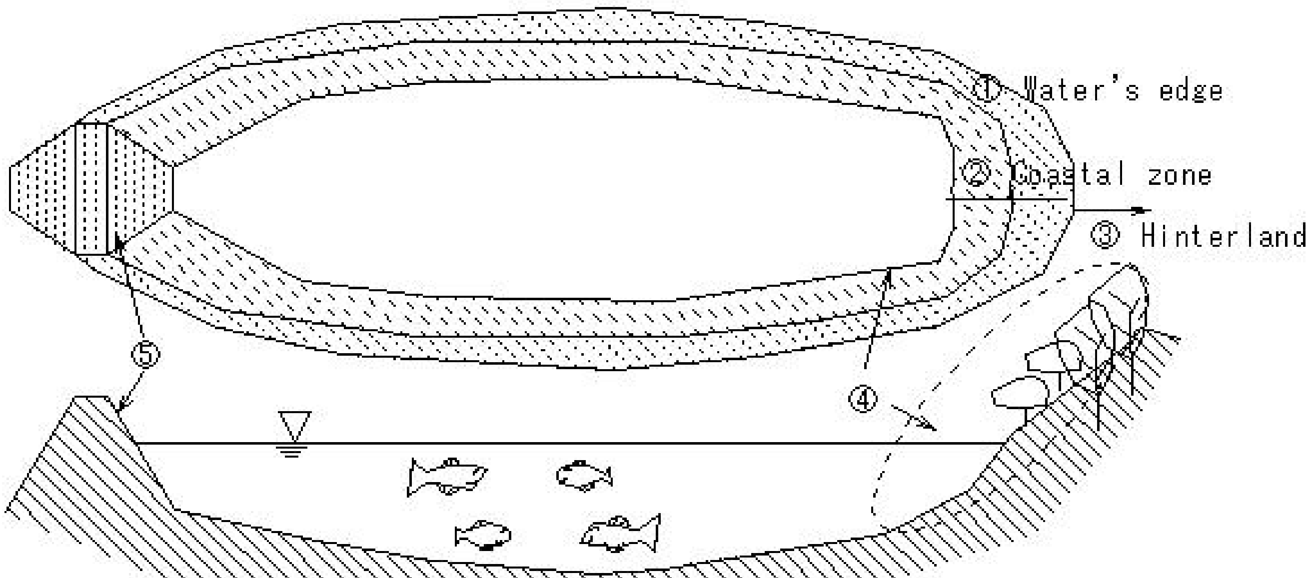


Figure 1.2.1 Environmentally-conscious scope of reservoirs

(I1623) Reservoir Development

(I1623) Reservoir Development

1.4 Basic design points

Reservoir renovation design

①Ensuring reservoir functionality

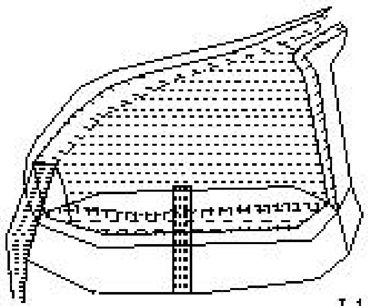
②Structural safety

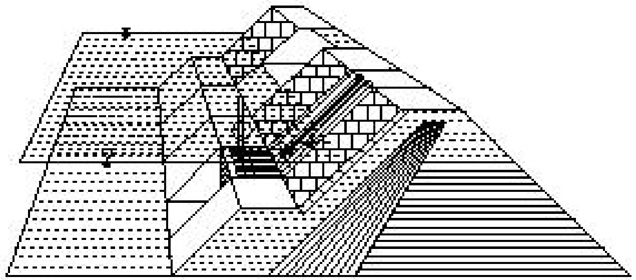
③Easy and economical construction

④Consider maintenance after construction

⑤Environmental harmony

⑥Earthquake resistance





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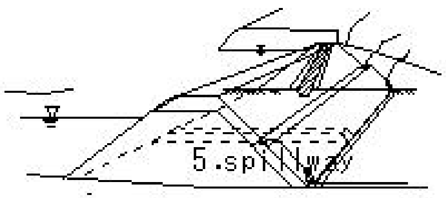

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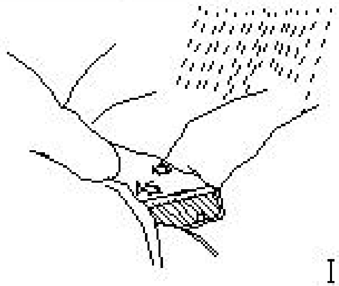

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(I1624) Reservoir Development

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1.4 Basic design points

Figure 1.4.1 Structure of reservoir facilities

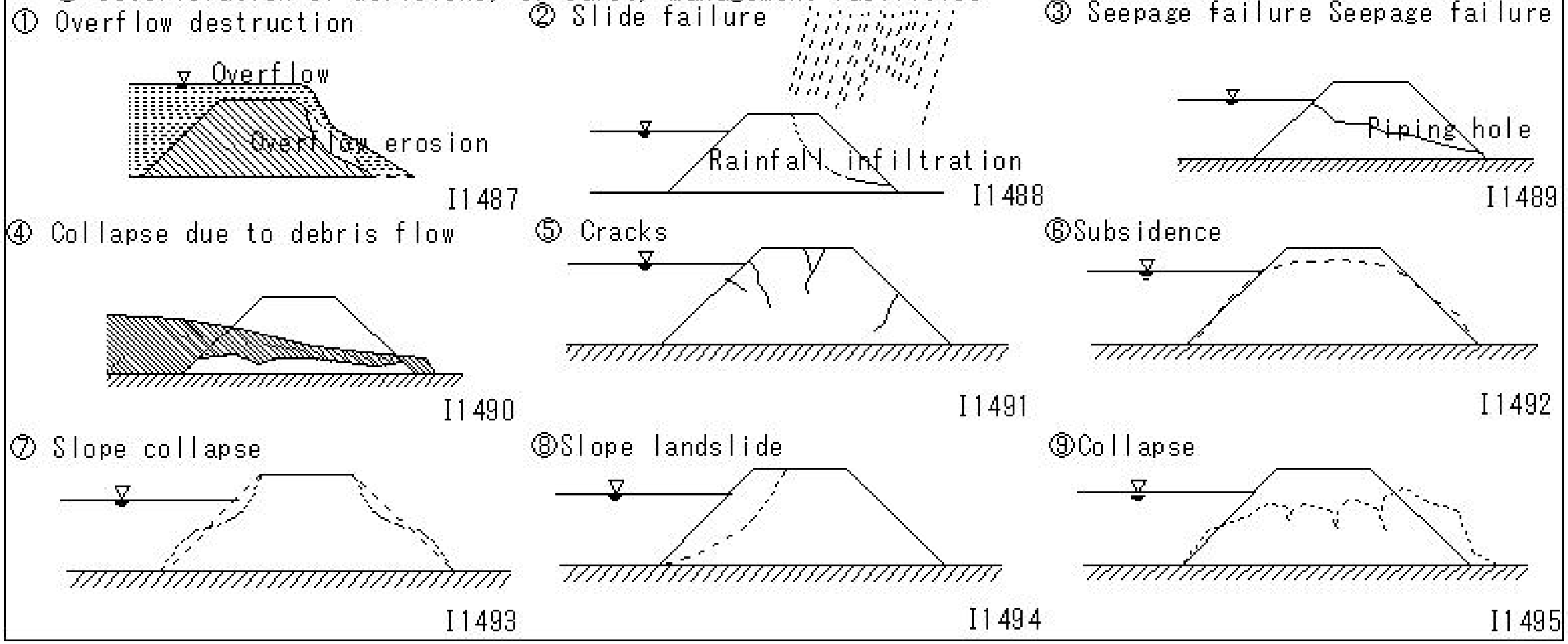
①Reservoir	②Embankment	③Embankment	④Uniform type
			⑤Inclined water-impermeable zone type
			⑥Central water-impermeable zone type
			⑦Surface water-impermeable wall type
			⑧Embankment grout type
		⑨Embankment ancillary structures	⑩Revetment work
			⑪Administration road
	⑫Spillway	⑬Inlet	⑭Channel inlet type
			⑮Overflow weir type
			⑯Side channel type
		⑰Conduction section	⑱Chute type
			⑲Blocking wall and step type
		⑳Energy dissipation section	㉑Hydrop type
			㉒Impact type
			㉓Drop type
	㉔Intake facility	㉕Intake section	㉖Inclined culvert
			㉗Intake tower
		㉘Conduction section	㉙Bottom culvert
			㉚Intake tunnel
	㉛Sand spit		
	㉜Emergency discharge facility		

(I1625) Reservoir Development

(I1625) Reservoir Development

1.5 Determination of need for repair

① Leaking from embankments, etc.
② Cracks and deformation of embankments
③ Insufficient clearance of embankments
④ Deformation of embankment cross-sectional shape
⑤ High infiltration line position
⑥ Deterioration of spillway function or insufficient water flow cross-section
⑦ Deterioration of water intake facilities
⑧ Deterioration or deficiency of safety management facilities



(I1626) Reservoir Development

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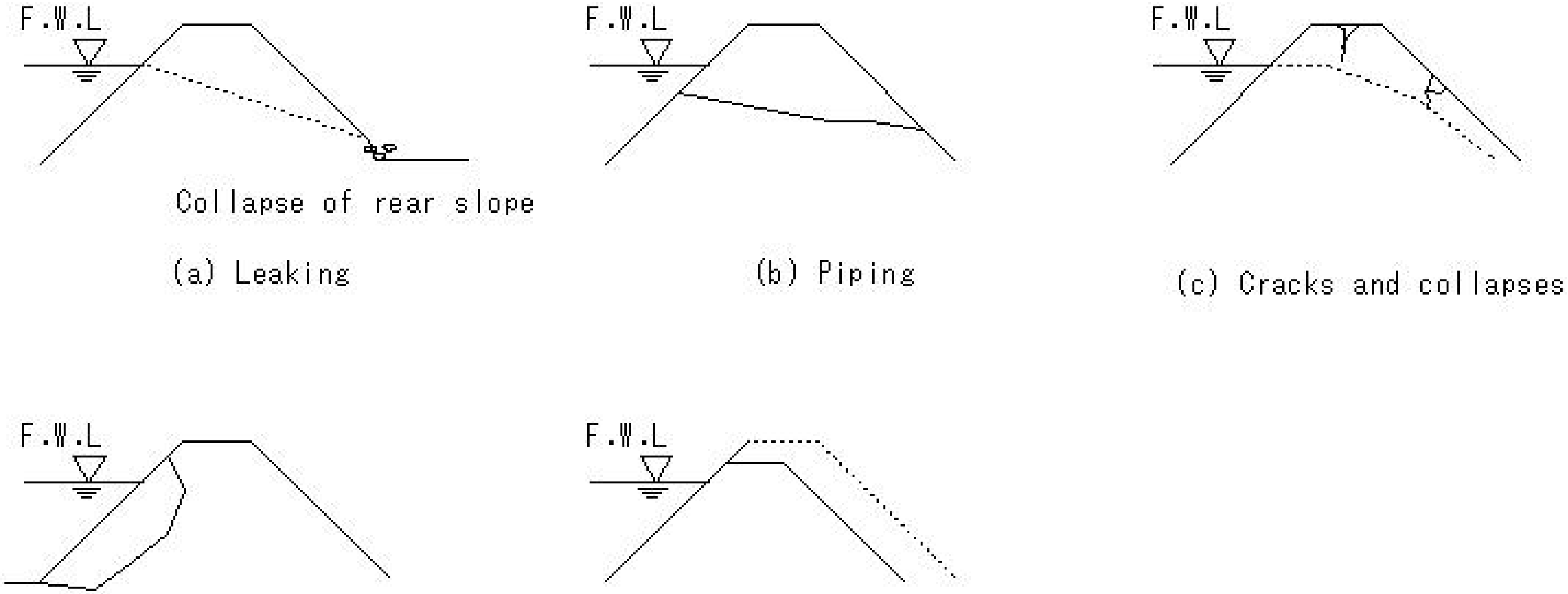
1.5 Determination of need for repair

1.5.1 Condition of embankment requiring repair



(a) Leaking

(b) Piping

(c) Cracks and collapses

(d) Cross-sectional deformation

(e) Insufficient clearance

(I1627) Reservoir Development

(I1627) Reservoir Development
1.6 Design procedure
Reservoir renovation design

① Design of main structures

② Reservoir structure and function survey

③ Calculation of design flood flow

④ Selection of reservoir renovation method

⑤ Design of embankment

⑥ Design of embankment ancillary structures

⑦ Design of spillway

⑧ Design of water intake facilities

⑨ Design of other structures

⑩ Environmental considerations

⑩ Environmental considerations

⑪ Environmental survey (preliminary survey)
・ Literature survey
・ Interview survey
・ Field survey

⑫ Degree of environmental impact
・ Low
・ High

⑬ Field survey (detailed survey)

⑭ Setting of conservation targets

⑮ Selection of areas
・ Consideration of consideration measures

⑯ Environmental considerations for embankment area

⑰ Environmental considerations for other areas

(I1628) Reservoir Development

(I1628) Reservoir Development

2.1.2 Geological survey and soil testing

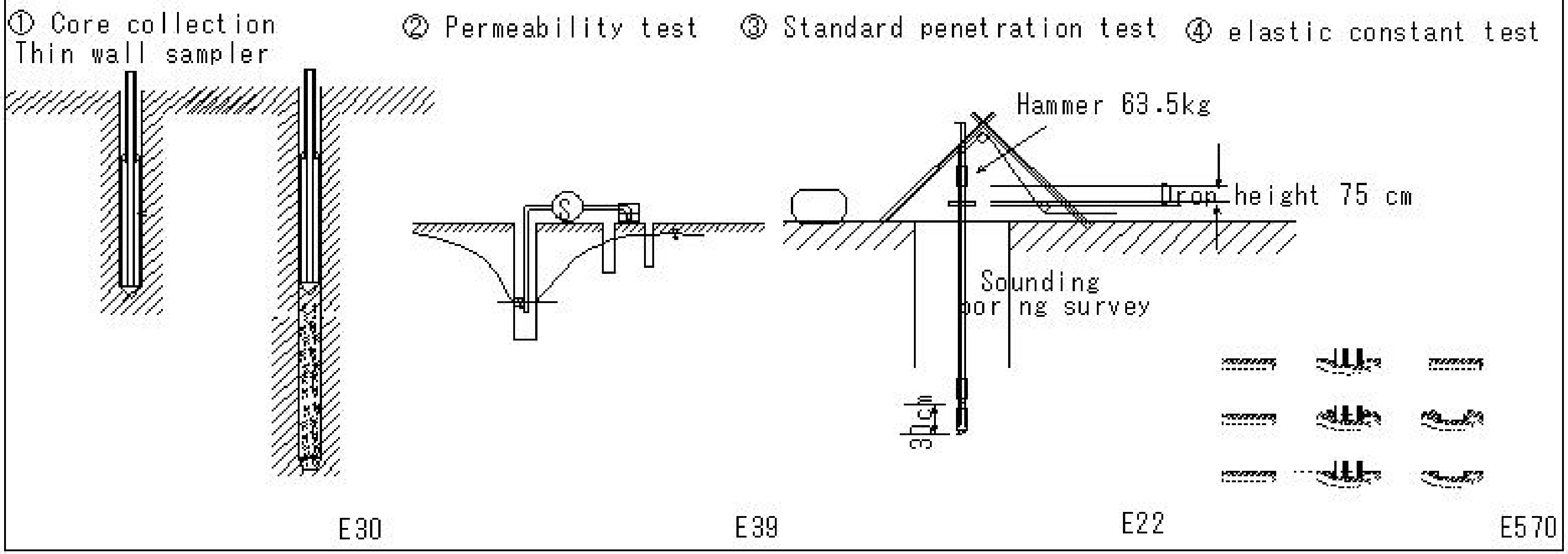
Figure 2.1.1 Types and purposes of boring surveys

① Core collection (geological survey of embankment and ground)

② Permeability test (permeability test of embankment and ground)

③ Standard penetration test (strength of embankment and bearing capacity test of ground)

④ PS logging, density logging and hole size logging
(elastic constant test of embankment foundation ground)



(I1629) Reservoir Development

(I1629) Reservoir Development

2.1.2 Geological survey and soil testing

Figure 2.1.1 Types and purposes of boring surveys

⑤ Understanding of embankment soil

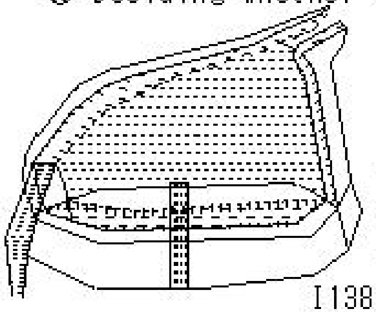
⑥ Understanding of foundation ground geological condition (horizontal and longitudinal)

⑦ Deciding whether to reuse embankment fill material as it is

⑧ Checking of sedimentary mud in the pond

⑨ Deciding on excavation depth

⑩ Deciding whether to use water-proofing method (grout, sheet pile, blanket, etc.)



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⑤ embankment soil

⑥ foundation ground geological condition

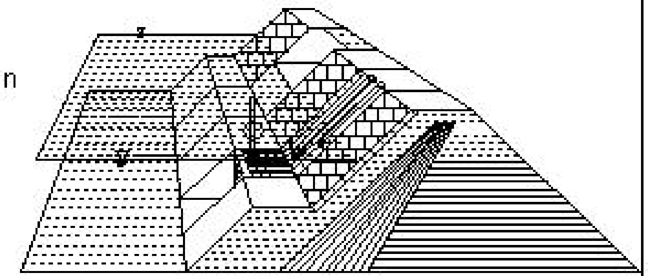
⑦ reuse embankment fill material

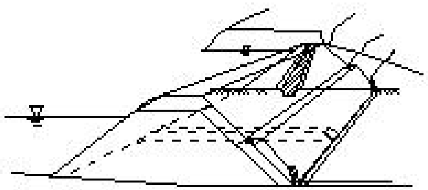
⑧ sedimentary mud in the pond

⑨ excavation depth

⑩ water-proofing method

boring survey





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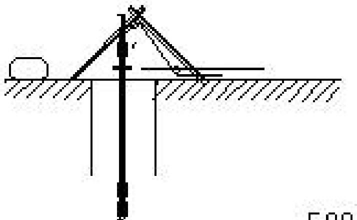

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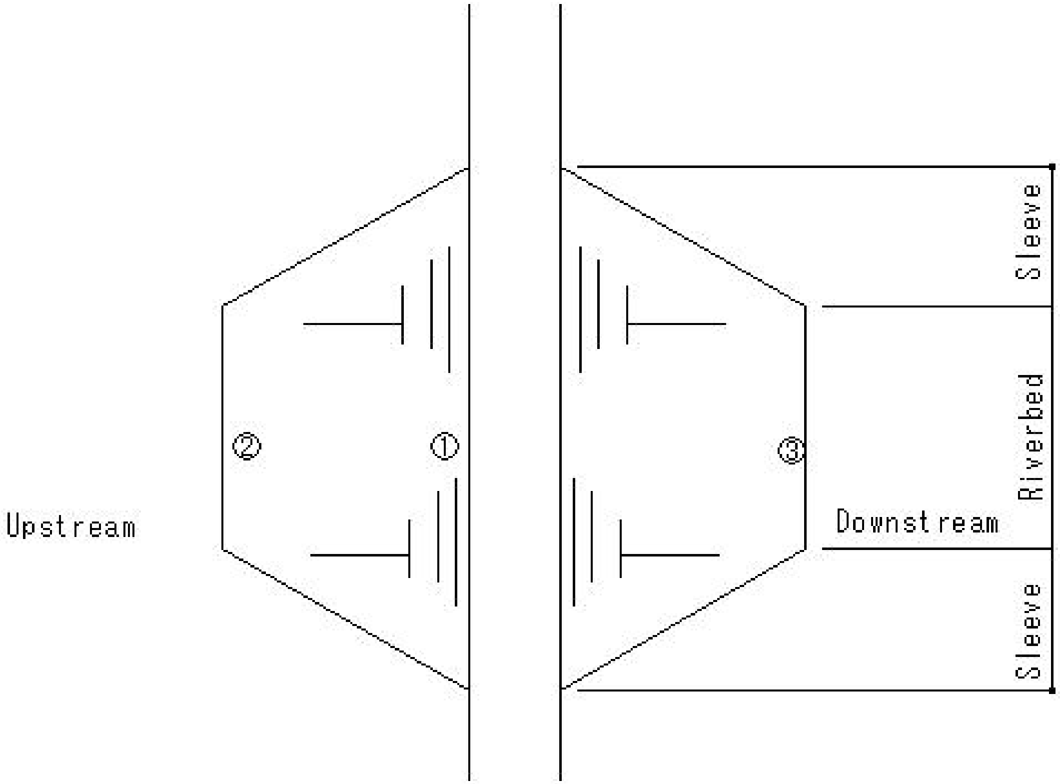
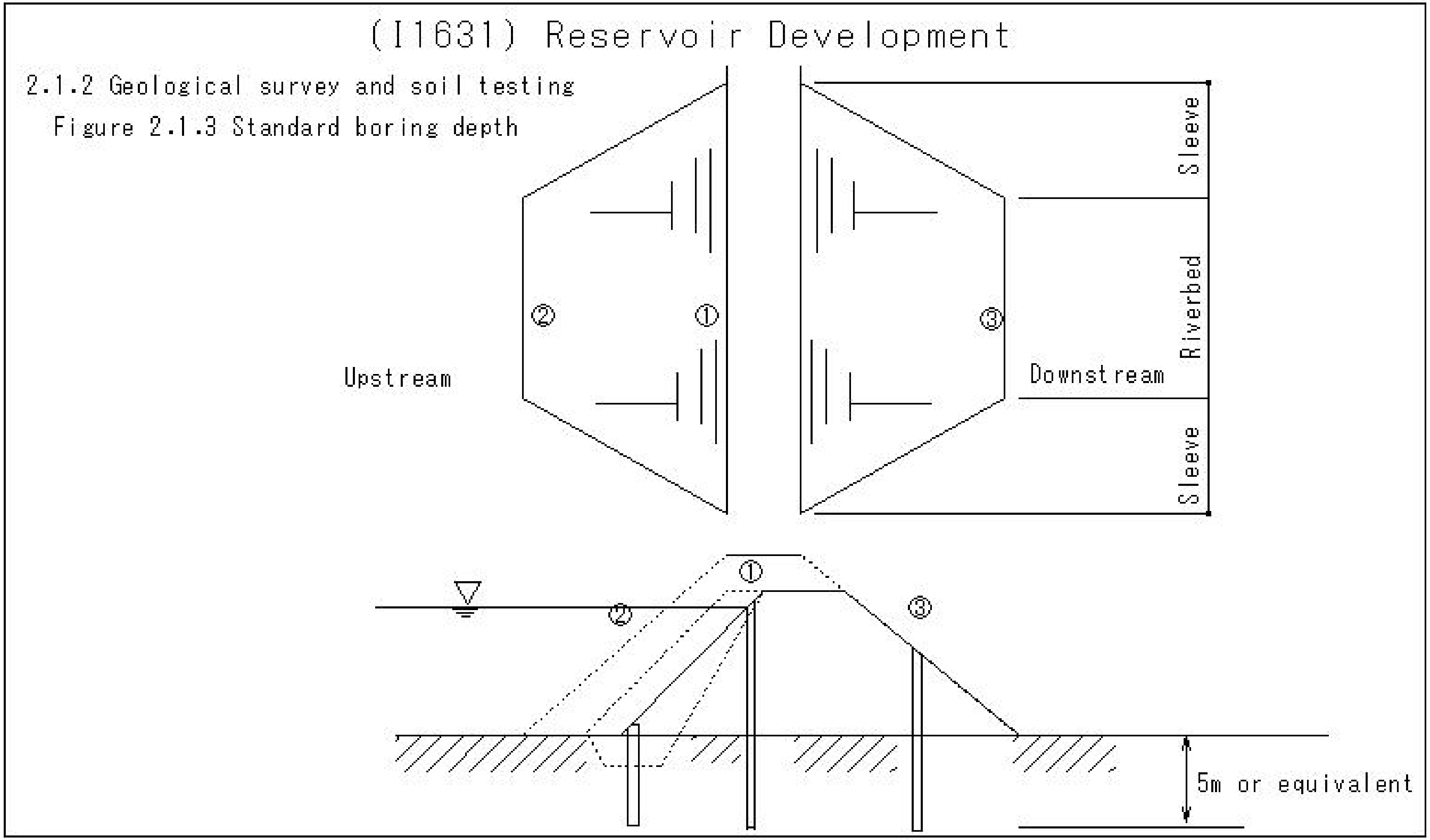
(I1630) Reservoir Development

2.1.2 Geological survey and soil testing

Figure 2.1.2 Standard example of boring location and number



(I1631) Reservoir Development



(I1632) Reservoir Development

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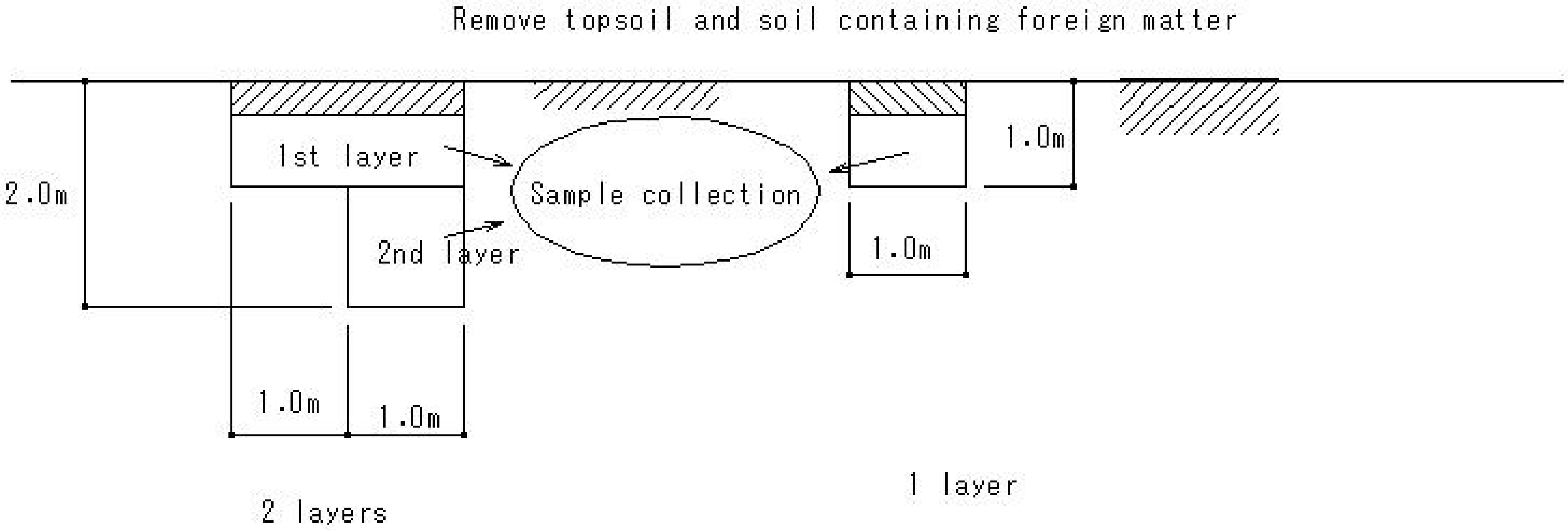
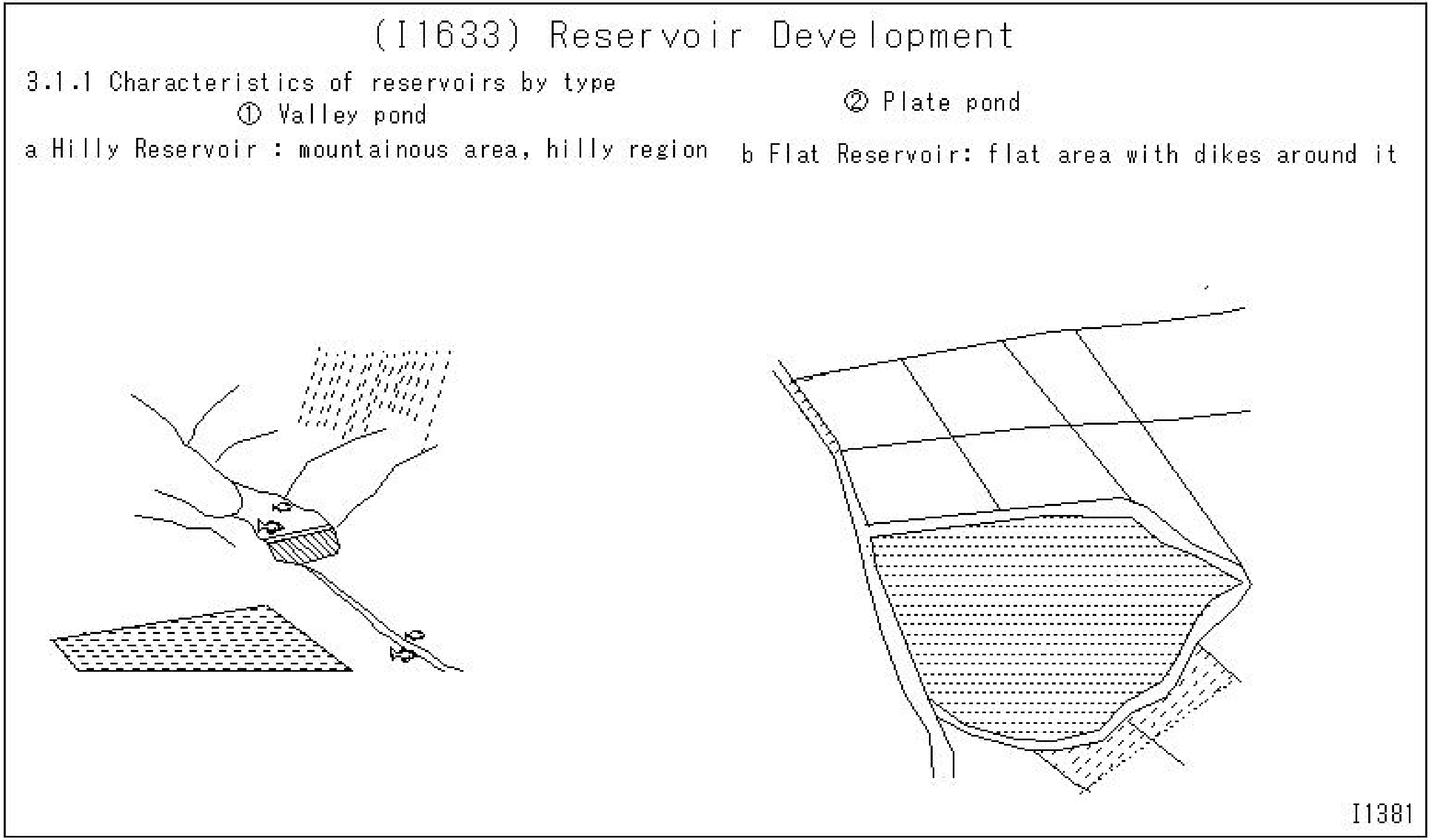
2.2 Material survey

Geological survey and soil tests are carried out to clarify the properties of embankment materials

Figure 2.2.1 Example of test pile



(I1633) Reservoir Development



(I1634) Reservoir Development

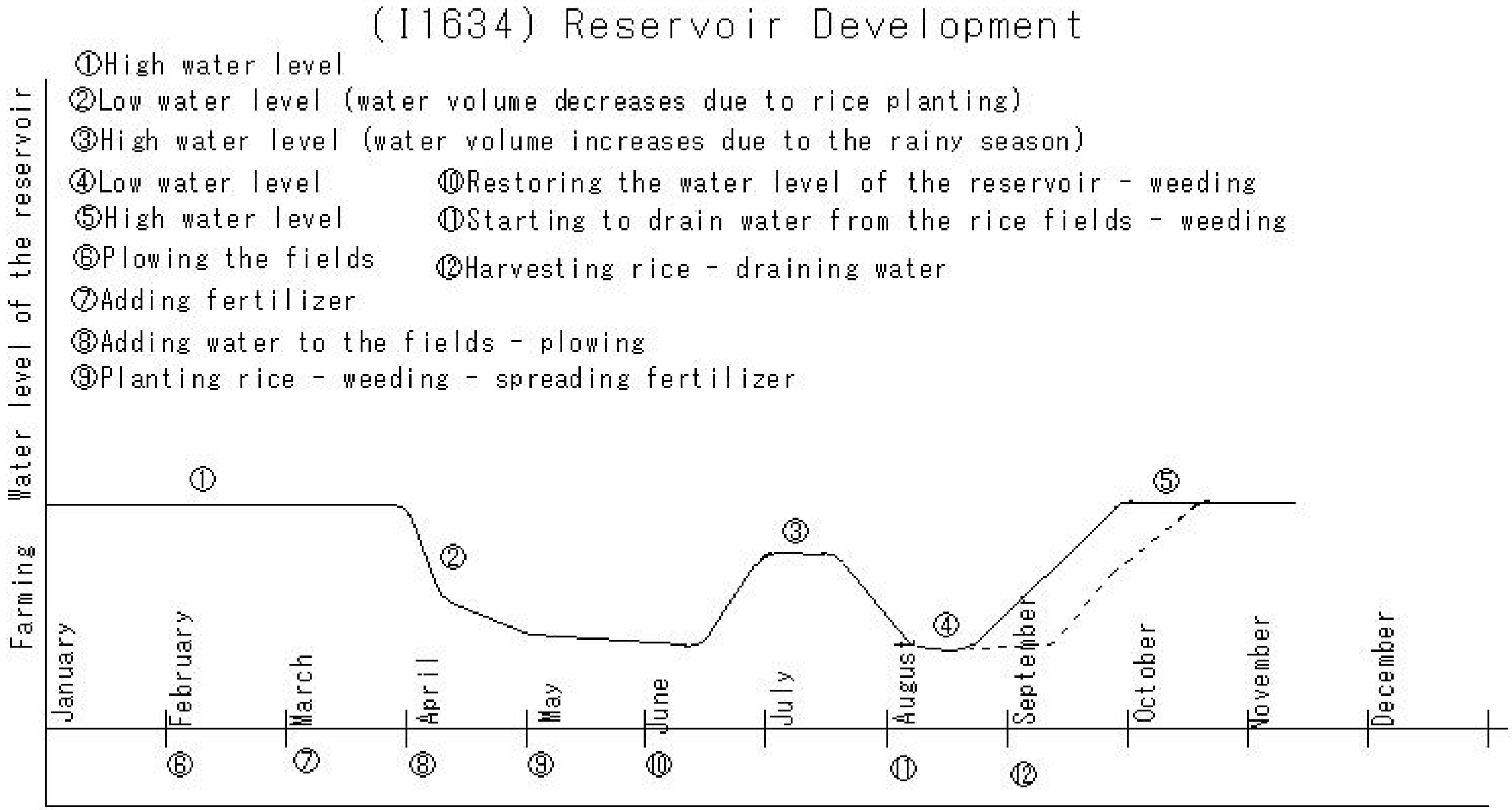
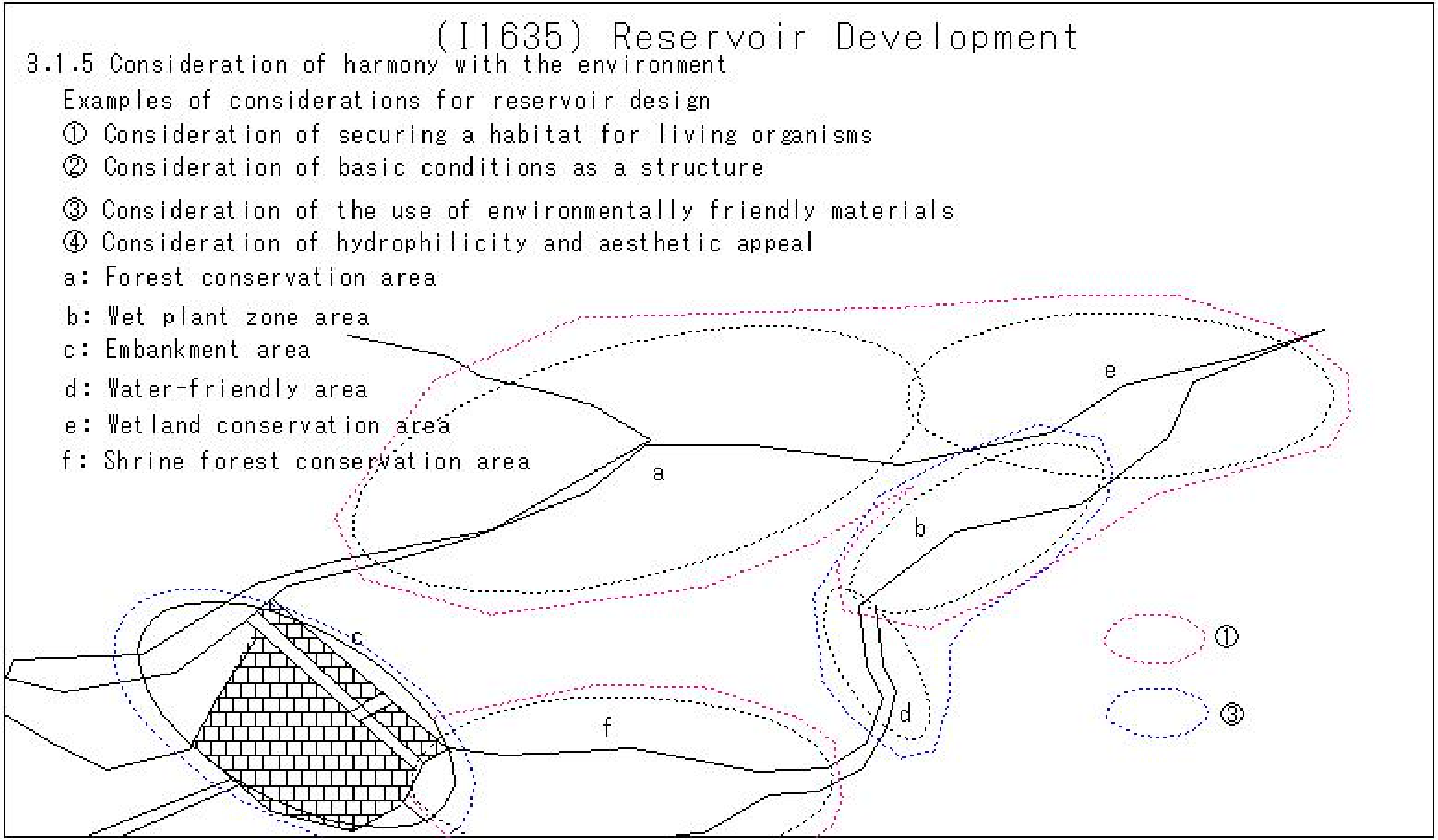


Figure 3.1.2 An example of the annual schedule of rice fields and the fluctuation of the water level of the reservoir

(I1635) Reservoir Development

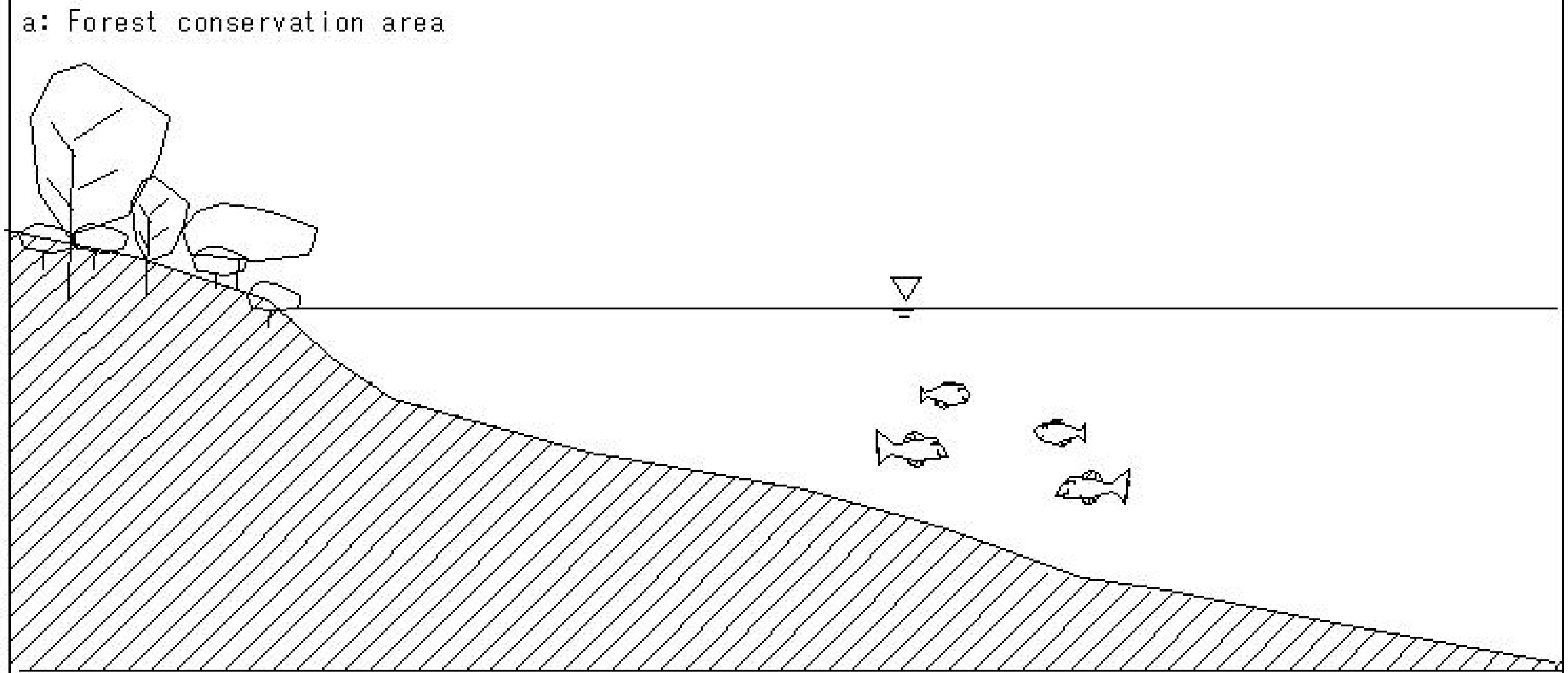


(I1636) Reservoir Development

(I1636) Reservoir Development

3.1.5 Consideration of harmony with the environment

Examples of considerations for reservoir design



① Consideration of securing a habitat for living organisms

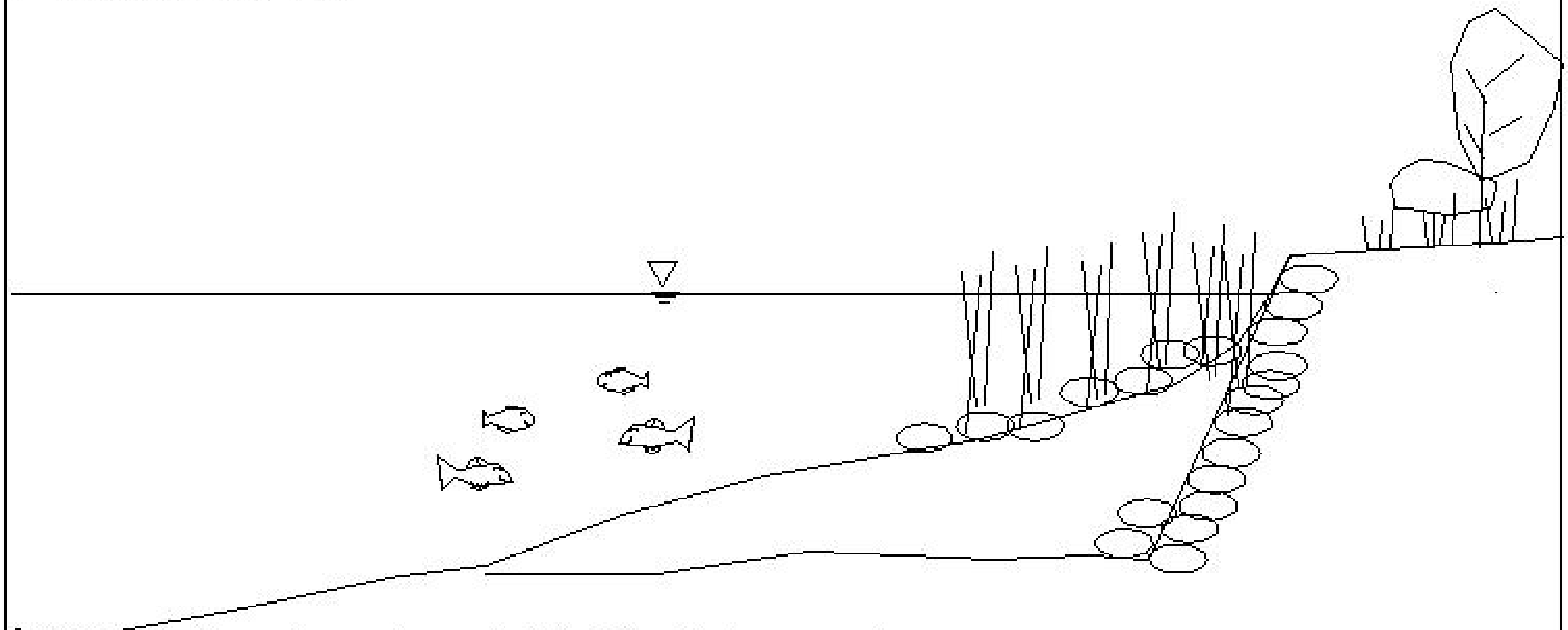
(I1637) Reservoir Development

(I1637) Reservoir Development

3.1.5 Consideration of harmony with the environment

Examples of considerations for reservoir design

b: Wet plant zone area



① Consideration of securing a habitat for living organisms

③ Consideration of the use of environmentally friendly materials

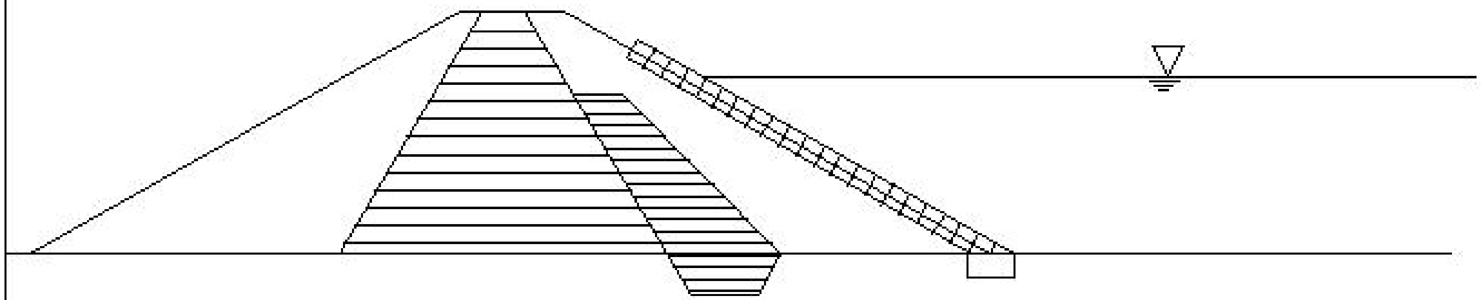
(I1638) Reservoir Development

(I1638) Reservoir Development

3.1.5 Consideration of harmony with the environment

Examples of considerations for reservoir design

c: Embankment area



② Consideration of basic conditions as a structure

③ Consideration of the use of environmentally friendly materials

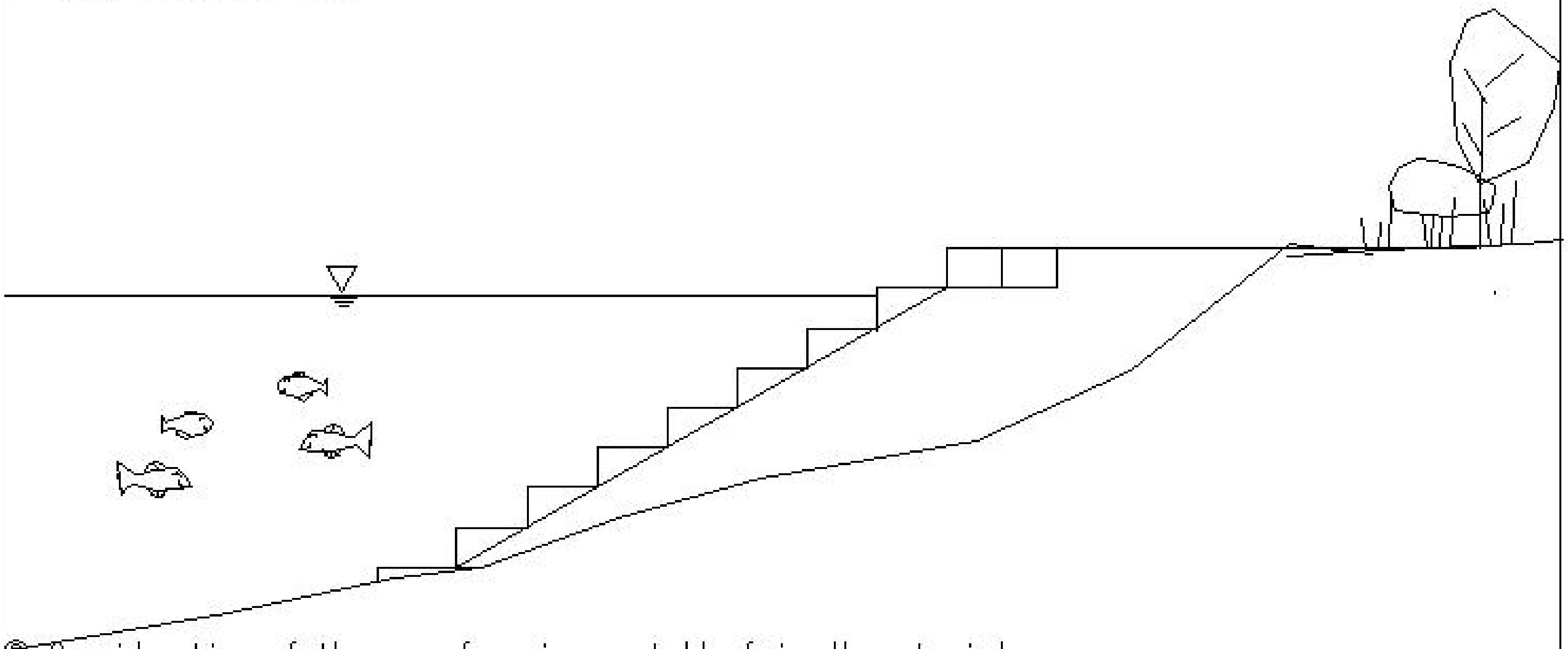
(I1639) Reservoir Development

(I1639) Reservoir Development

3.1.5 Consideration of harmony with the environment

Examples of considerations for reservoir design

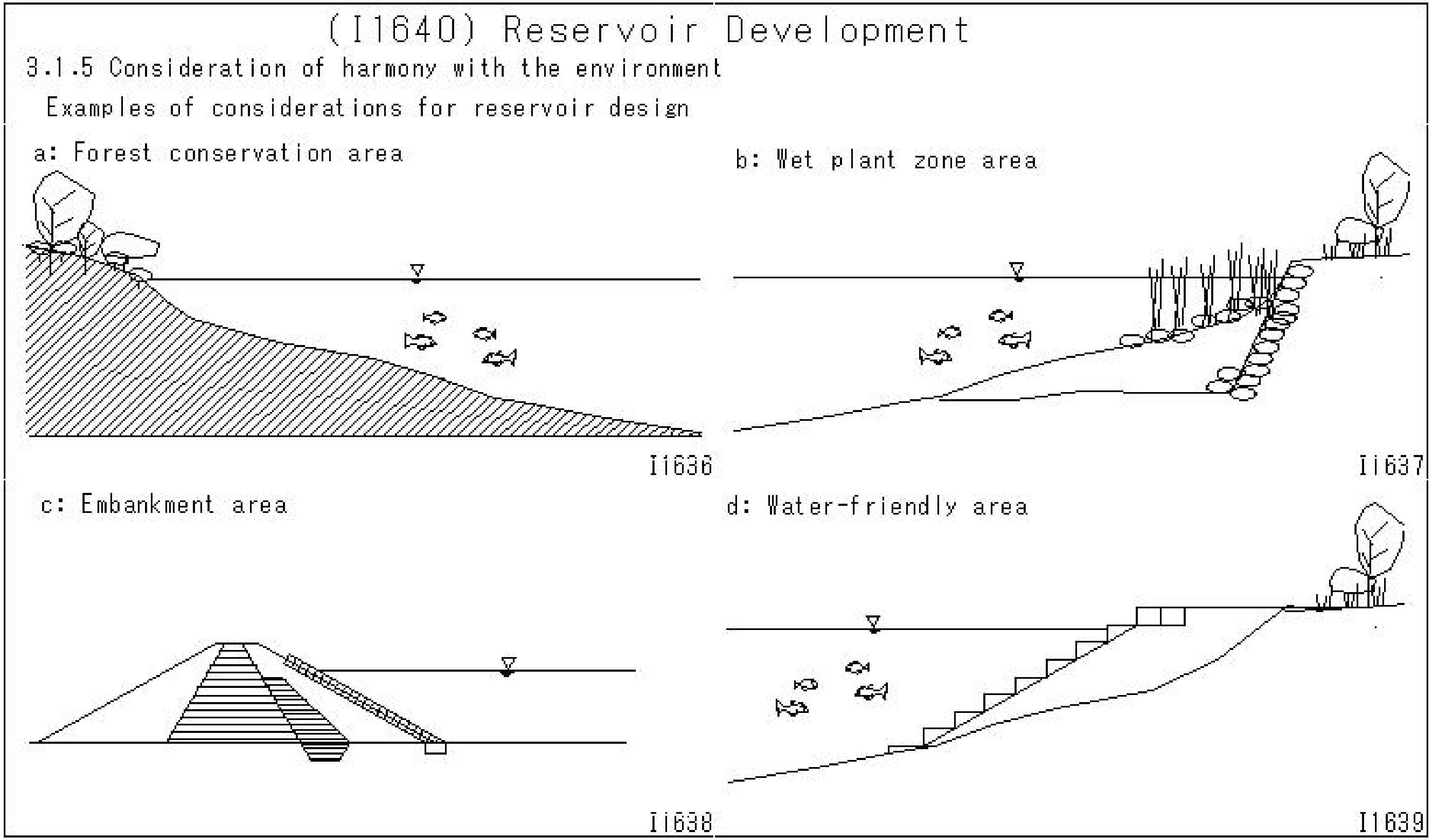
d: Water-friendly area



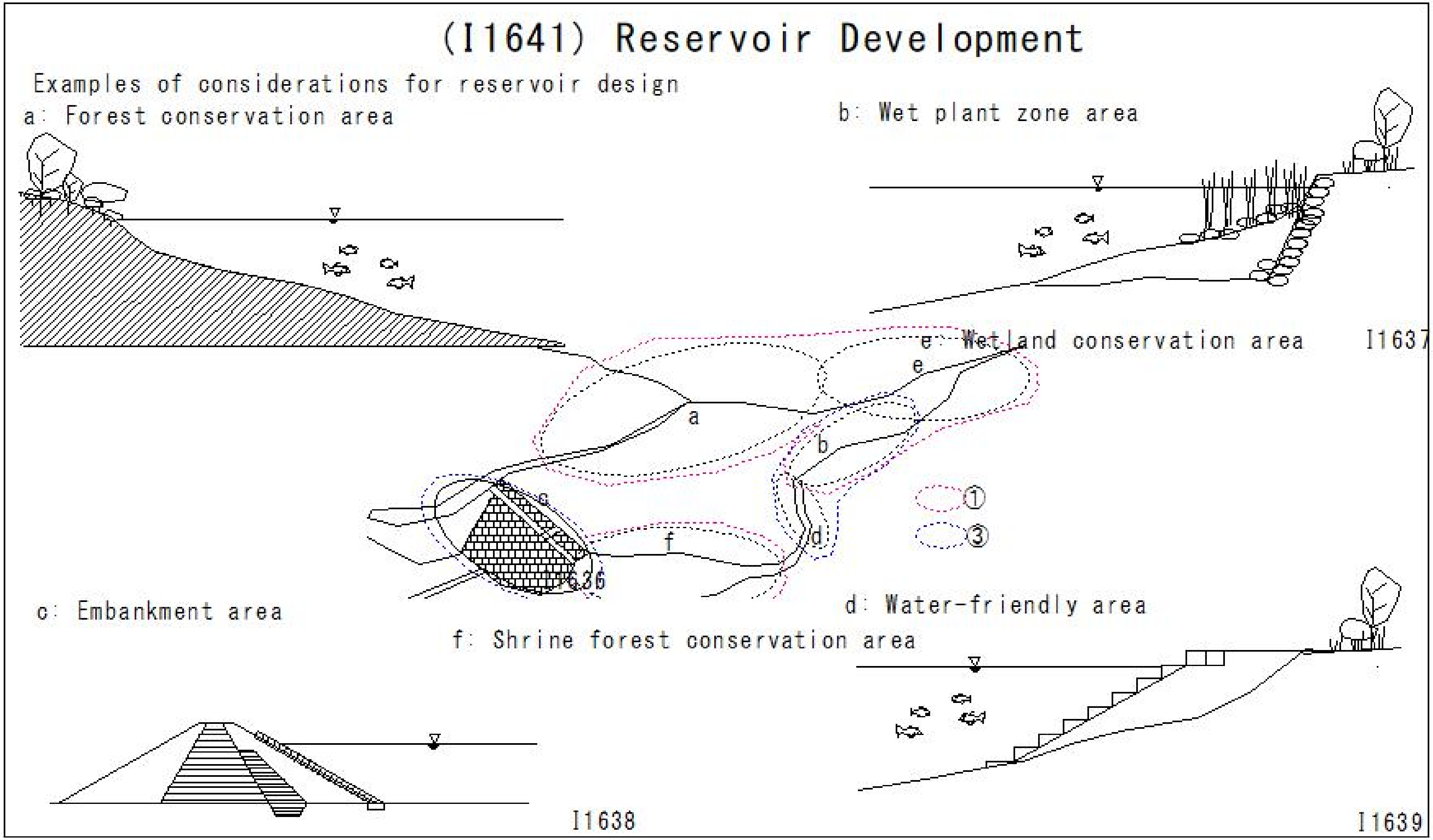
③ Consideration of the use of environmentally friendly materials

④ Consideration of hydrophilicity and aesthetic appeal

(I1640) Reservoir Development



(I1641) Reservoir Development

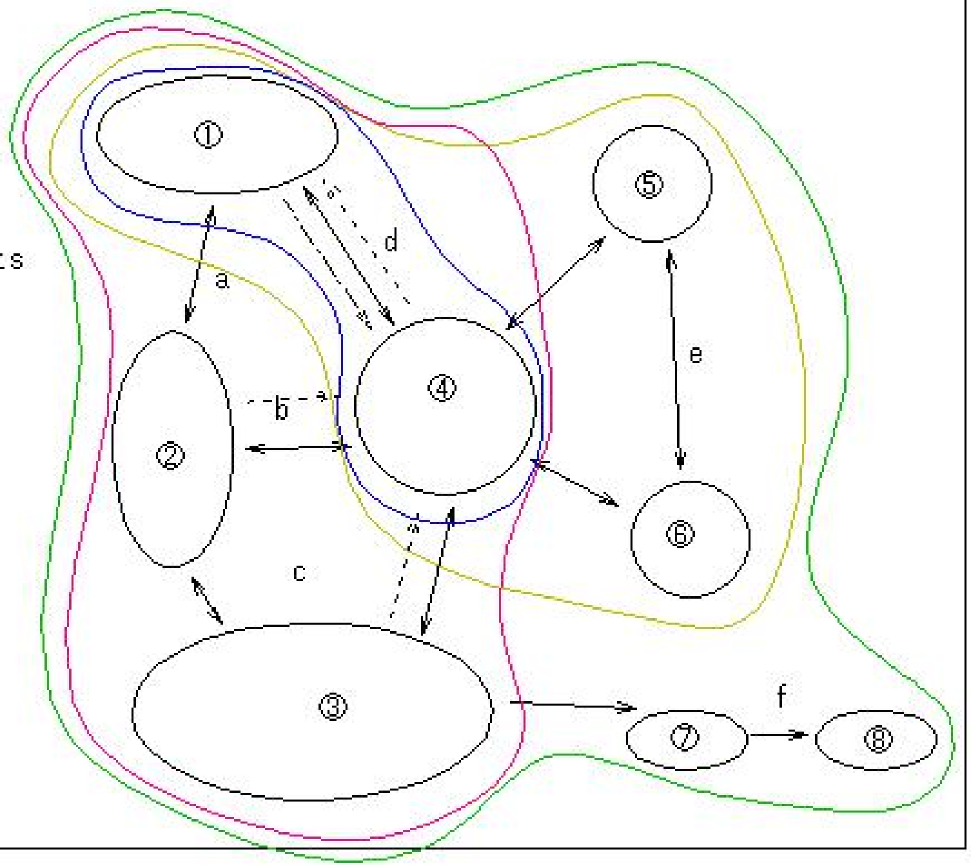


(I1642) Reservoir Development

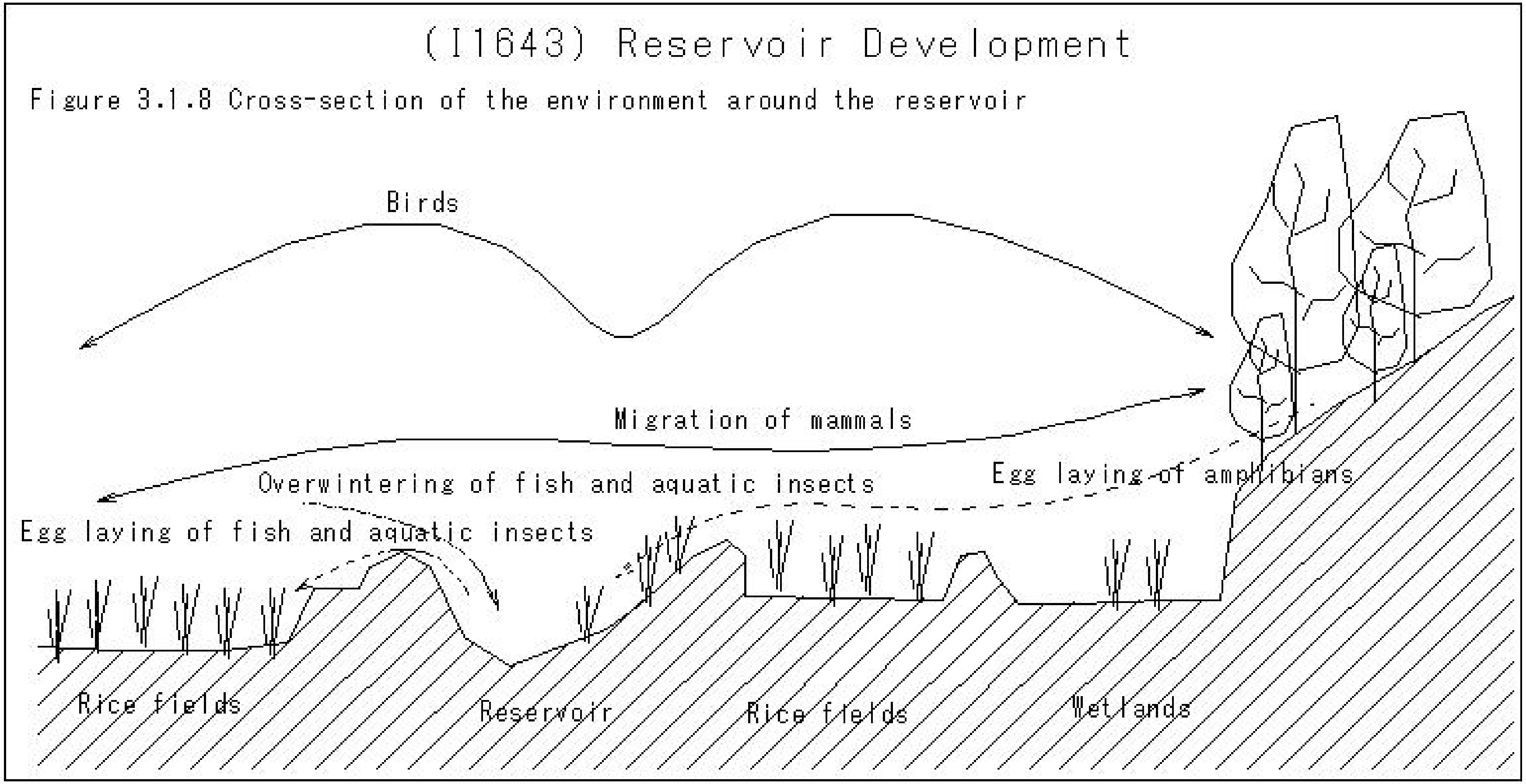
(I1642) Reservoir Development

Figure 3.1.7 Conceptual diagram of the network between reservoirs and their surrounding environment

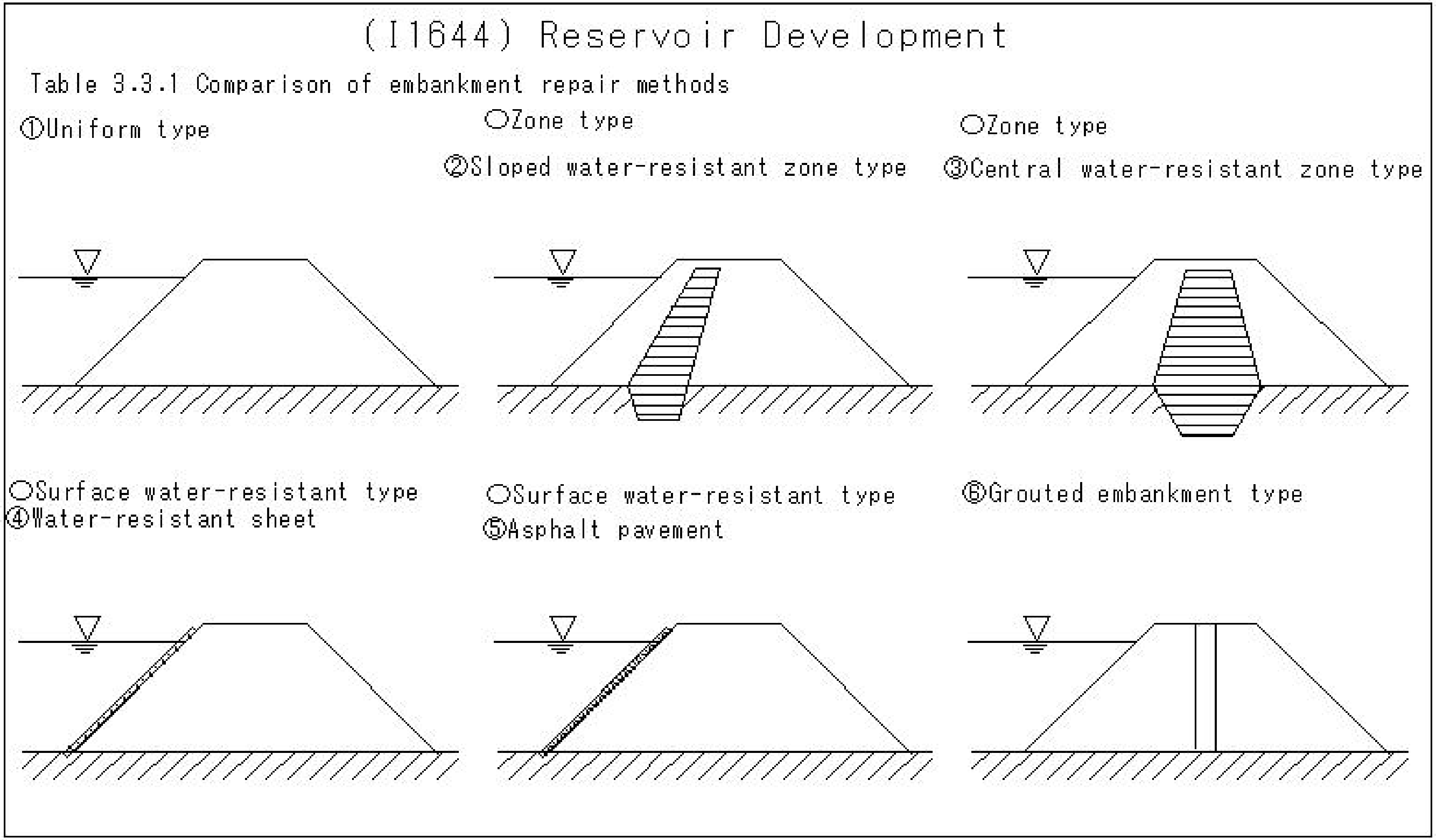
①Hidden area (paddy fields)
②Hidden area (wetlands)
③Hidden area (satoyama, woodland)
④Reservoir ⑤Reservoir ⑥Reservoir
⑦Downstream waterway
⑧Downstream rice fields
a Overwintering of fish and aquatic insects
b Egg laying of amphibians
c Egg laying of amphibians
d Egg laying of fish and aquatic insects
e Migration of aquatic insects
f Fish
Aquatic insect range of movement
Fish Aquatic insect range of movement
Bird and mammal range of movement
Amphibians range of movement
----Egg laying
— - —Overwintering



(I1643) Reservoir Development



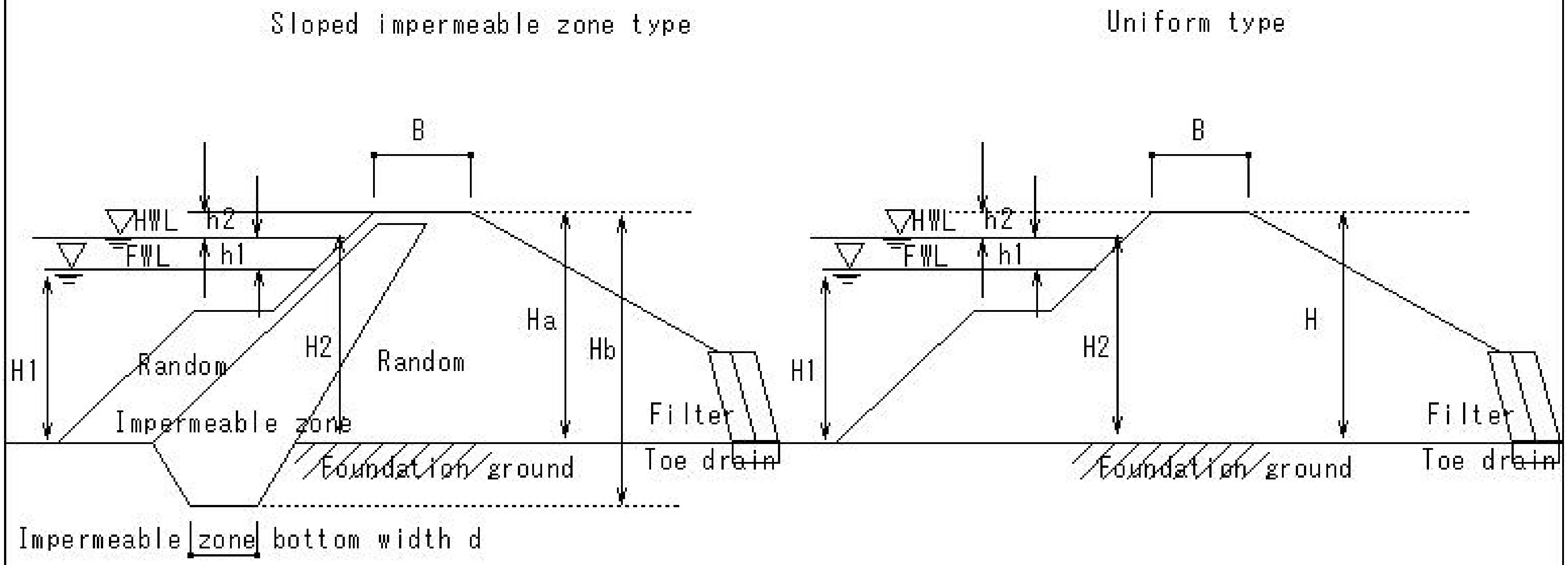
(I1644) Reservoir Development



(I1645) Reservoir Development

(I1645) Reservoir Development

Figure 3.3.2 Sections of the levee body of the sloped impermeable zone type and the uniform type



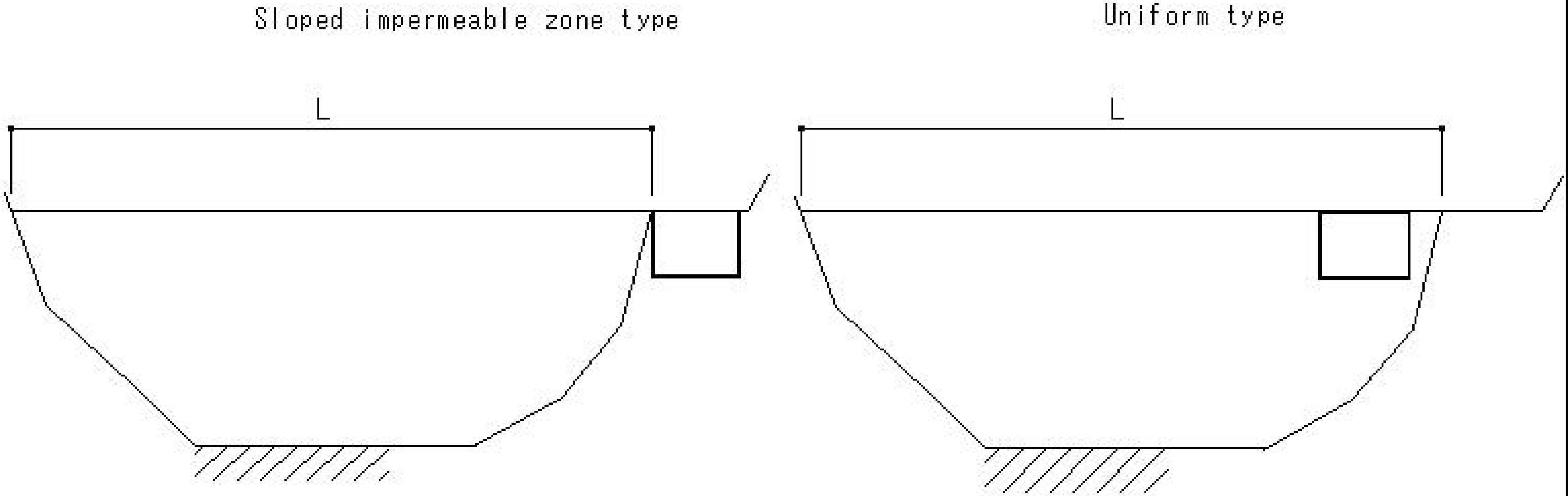
H: Embankment height
L: Embankment crest length
B: Embankment crest width
(HWL) Design high water level
(FWL) Continuous full water level

H1: Reservoir depth
H2: Maximum water depth
h1: Overflow depth
h2: Freeboard height

(I1646) Reservoir Development

(I1646) Reservoir Development

Figure 3.3.3 Embankment crest method



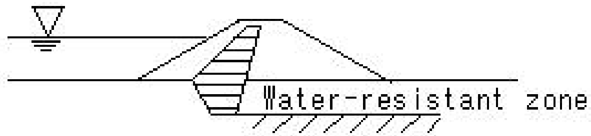
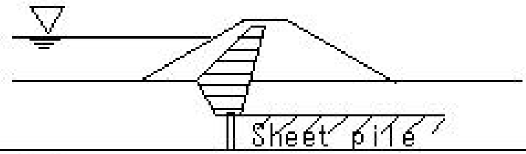
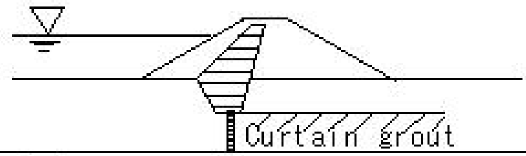
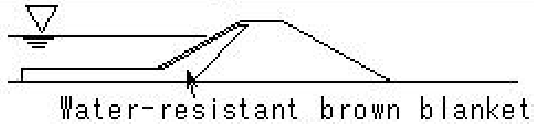
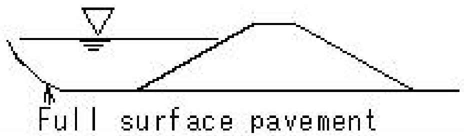
H: Embankment height
L: Embankment crest length
B: Embankment crest width
(HWL) Design high water level
(FWL) Continuous full water level

H1: Reservoir depth
H2: Maximum water depth
h1: Overflow depth
h2: Freeboard height

(I1647) Reservoir Development

(I1647) Reservoir Development

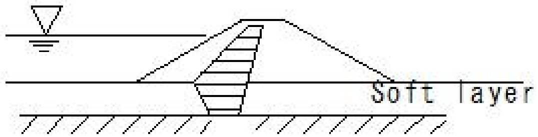
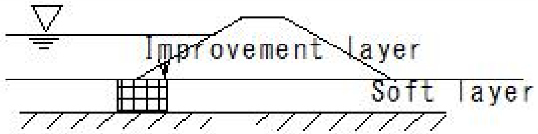
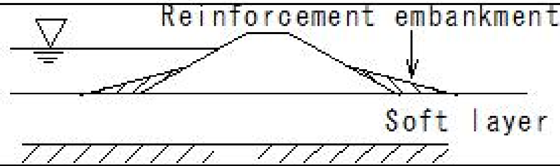
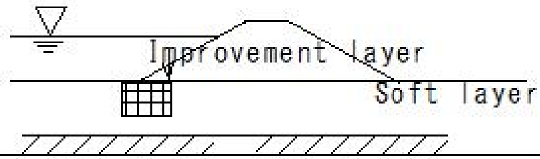
Figure 3.3.2 Treatment for permeable ground

① Permeable thickness	② Design method	③ Schematic diagram	④ Application
Thin	Water-resistant zone		Complete water -resistant effect
Medium	Sheet pile		Incomplete water-resistant effect Not suitable for layers containing boulders
Medium	Grout		Effective for bedrock permeability
Thick	Blanket		Effective for preventing piping Low cost
Thick	Full surface pavement		High cost In case of leakage is limited to a minimum

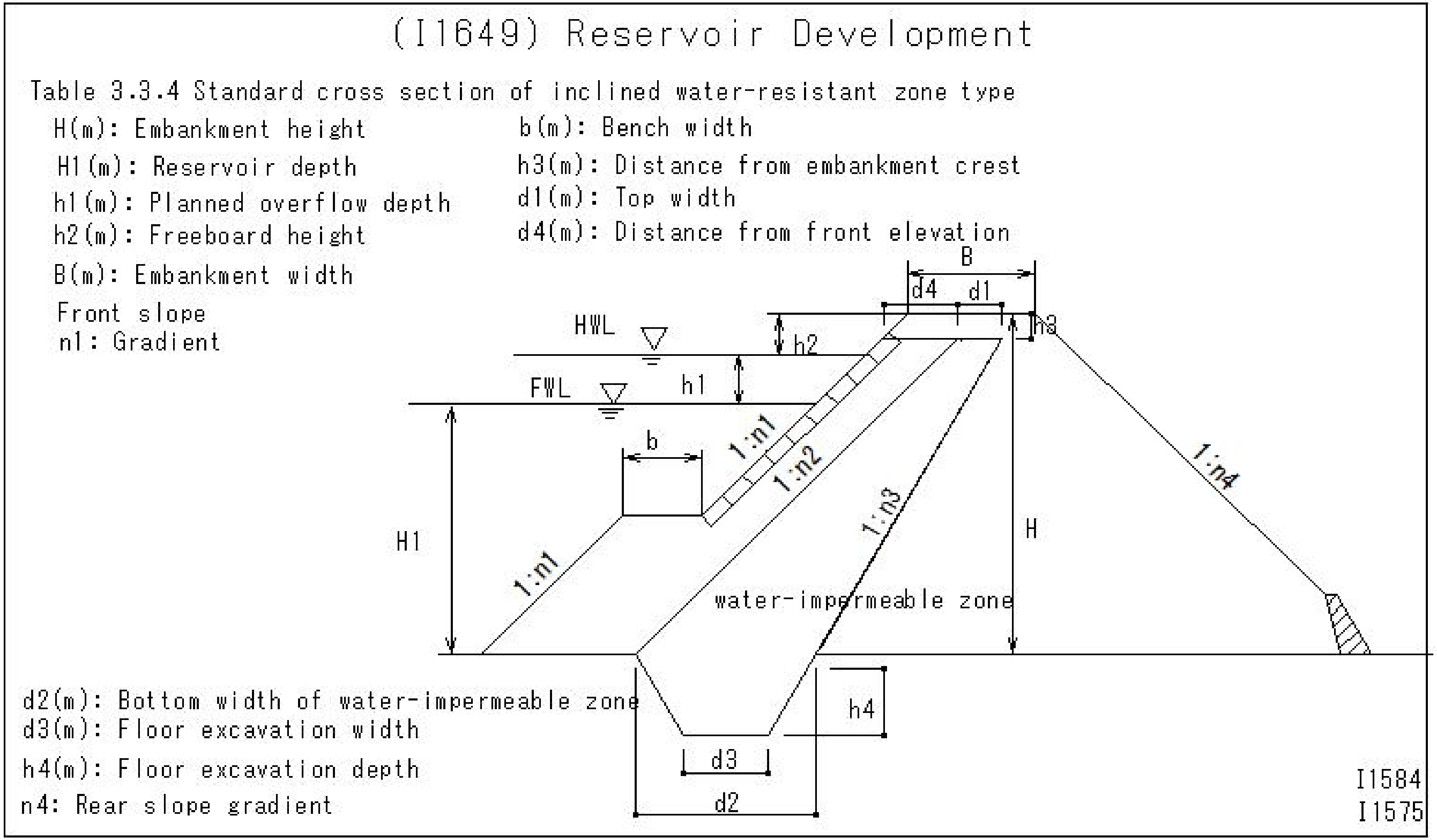
(I1648) Reservoir Development

(I1648) Reservoir Development

Table 3.3.3 Soft ground treatment methods

① Permeable thickness	② Design method	③ Schematic diagram	④ Application
Thin	Replacement method		Remove all or part of the weak layer and and replace it with a safer material
	Ground improvement		Mix with improvement material to the required depth of the soft layer to improve it to a safer material
Thick	Reinforcement embankment		Place reinforcement embankment at the end of the slope to prevent through the foundation surface
	Ground improvement		Mix with improvement material to the required depth of the soft layer to improve it to a safer material

(I1649) Reservoir Development



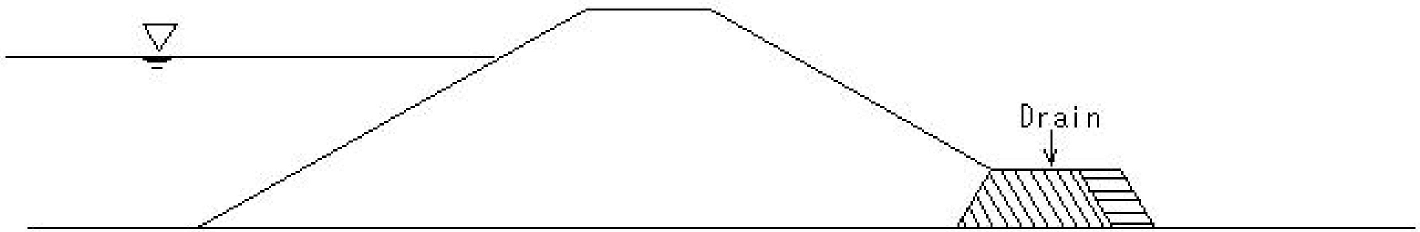
(I1650) Reservoir Development

(I1650) Reservoir Development

Table 3.3.10 Drain classification

(a) Downstream tip drain

Drain classification



(a) Downstream tip drain

Purpose

Promotes drainage of seepage water within the embankment and lowers the seepage line

Characteristics

Used when installation of (b) or (c) is difficult

Used during renovation

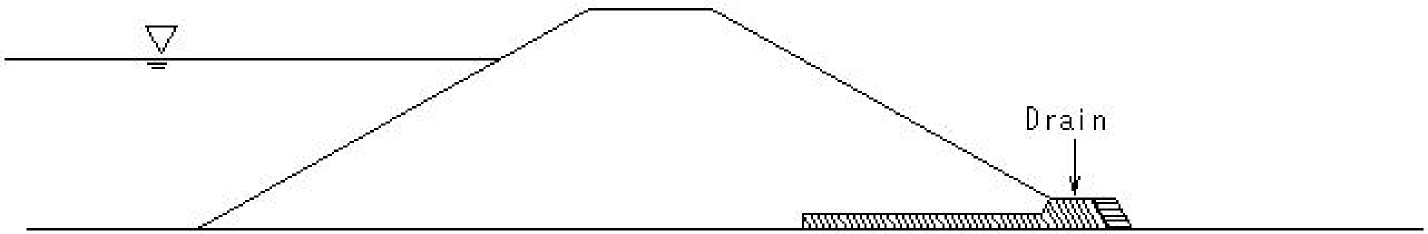
(I1651) Reservoir Development

(I1651) Reservoir Development

Table 3.3.10 Drain classification

(b) Horizontal drain

Drain classification



(b) Horizontal drain

Purpose

Promotes drainage of seepage water from the embankment and foundation and lowers the seepage line

Characteristics

Relatively effective in lowering the seepage line

Large-scale excavation of embankment embankment required

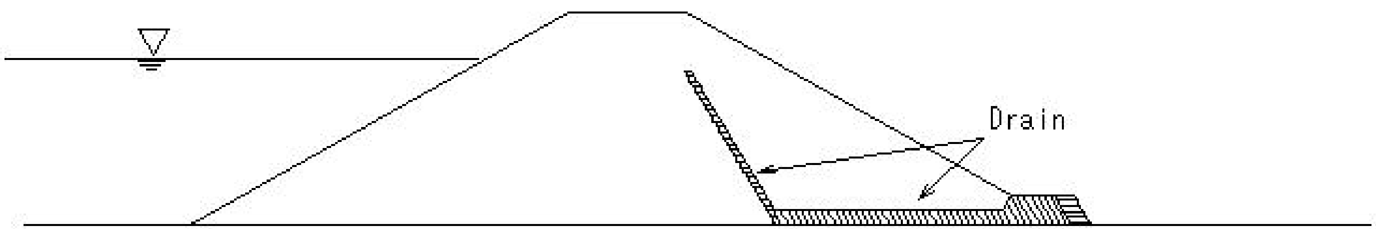
(I1652) Reservoir Development

(I1652) Reservoir Development

Table 3.3.10 Drain classification

(c) Rising drain

Drain classification



(c) Rising drain

Purpose

Promotes drainage of seepage water from inside the embankment and foundation

Reliably lowers the infiltration line at the rising drain section

Characteristics

Comparably effective at lowering the infiltration line

Since no infiltration line occurs downstream of the rising section,

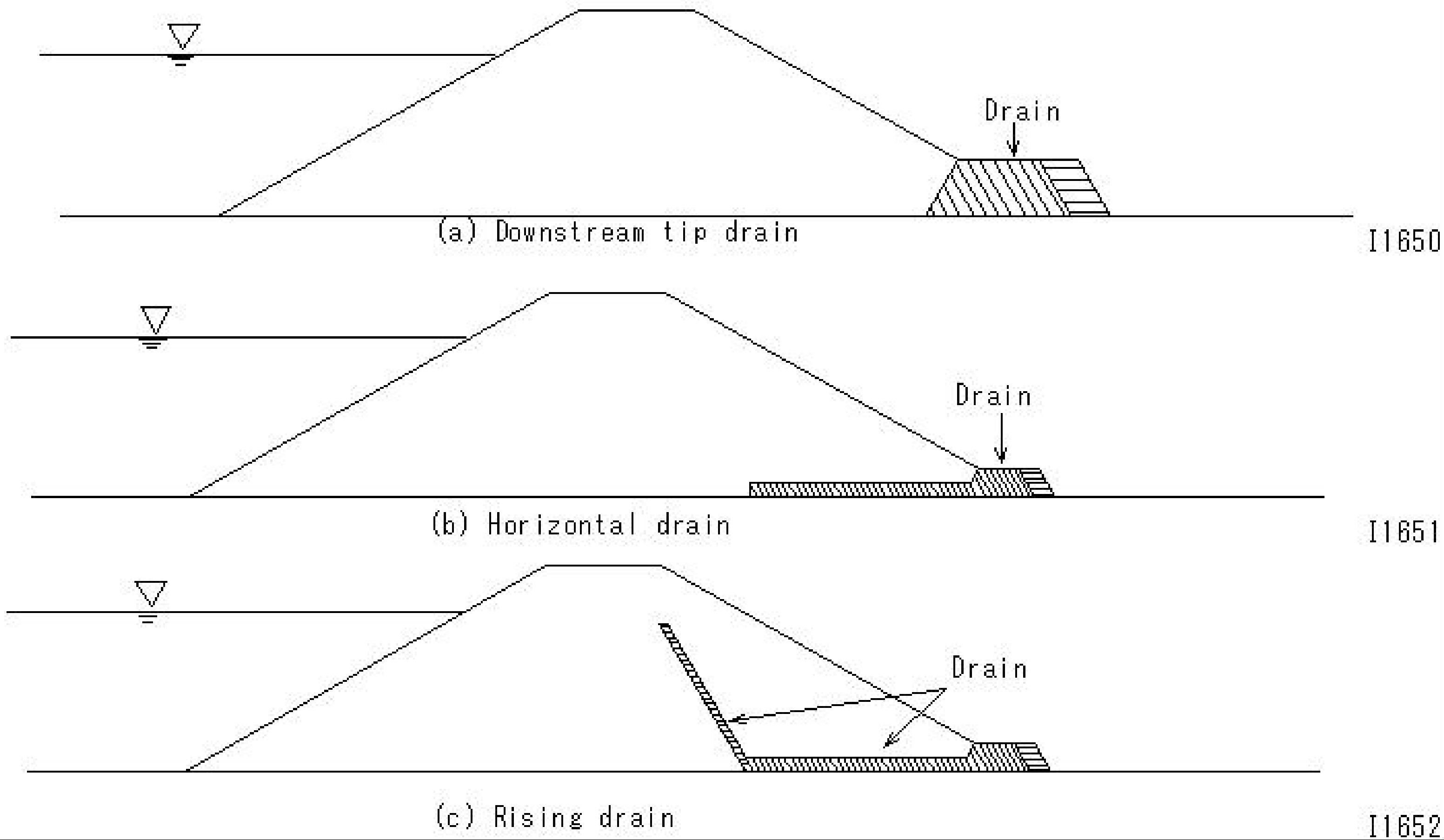
it is highly effective in stabilizing the embankment and preventing liquefaction

Large-scale excavation of the embankment embankment is required

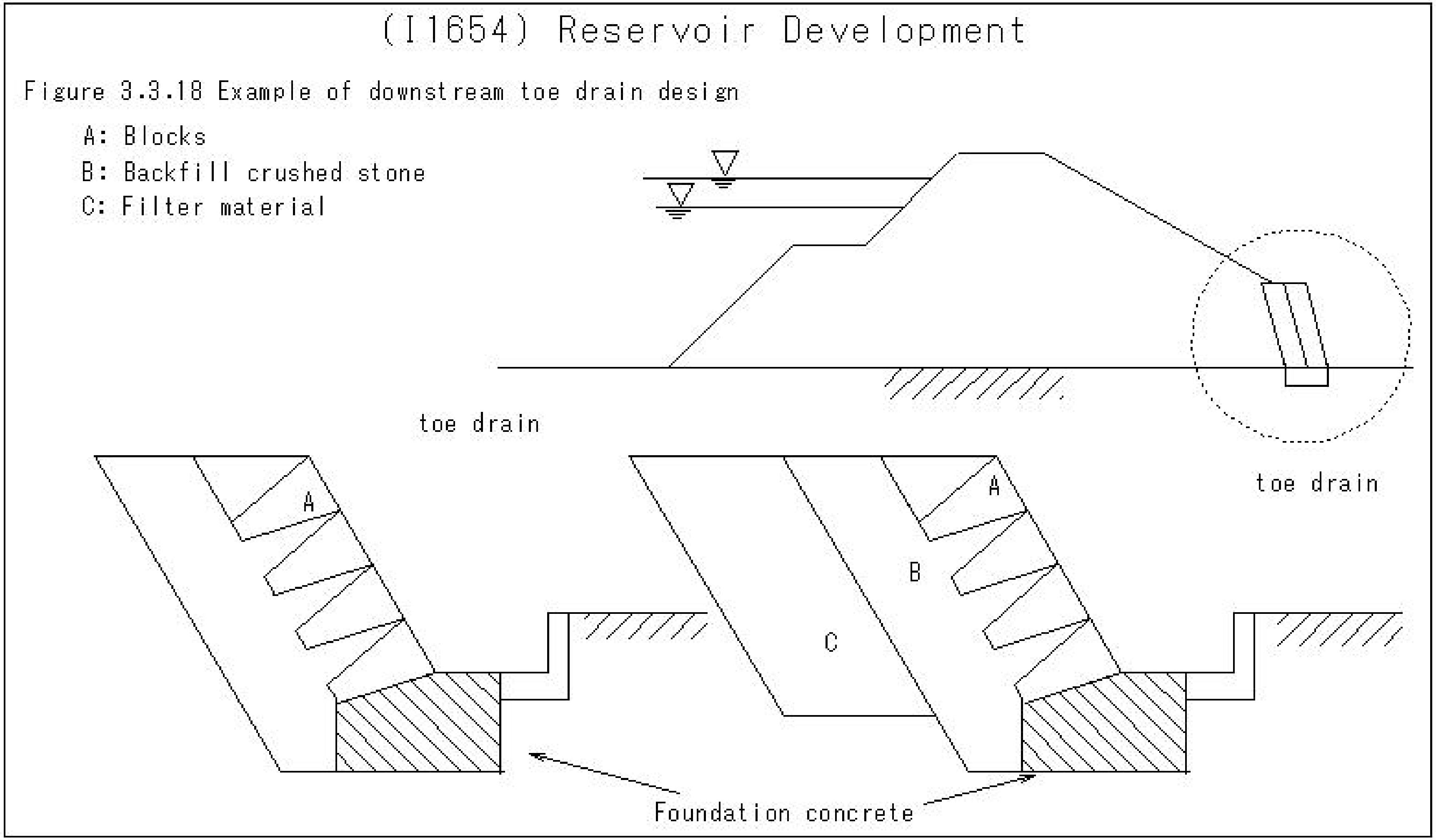
(I1653) Reservoir Development

(I1653) Reservoir Development

Table 3.3.10 Drain classification



(I1654) Reservoir Development



(I1655) Reservoir Development

(I1655) Reservoir Development

3.3.5 Slope protection works and safety facilities

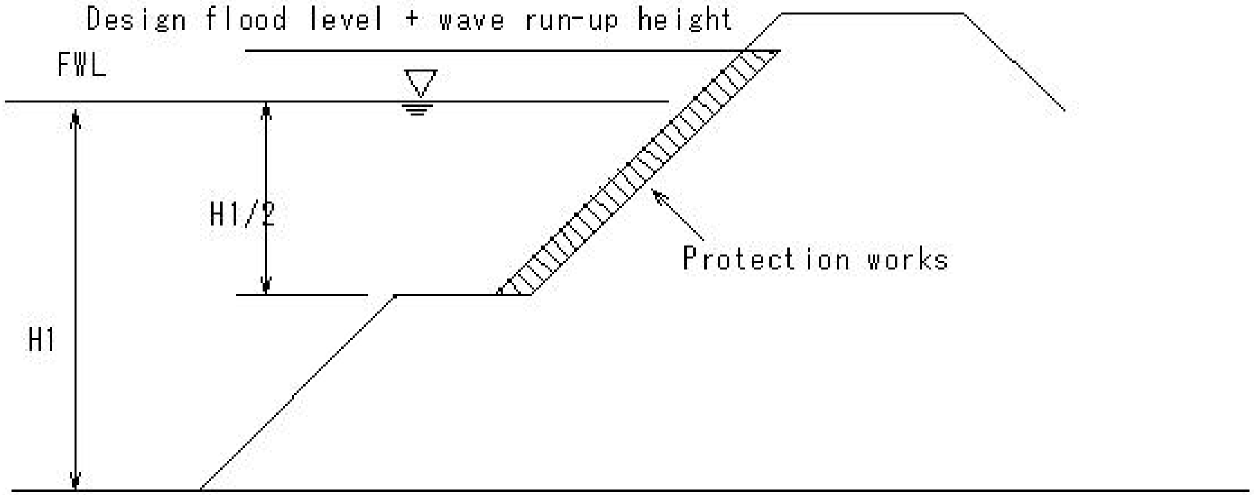
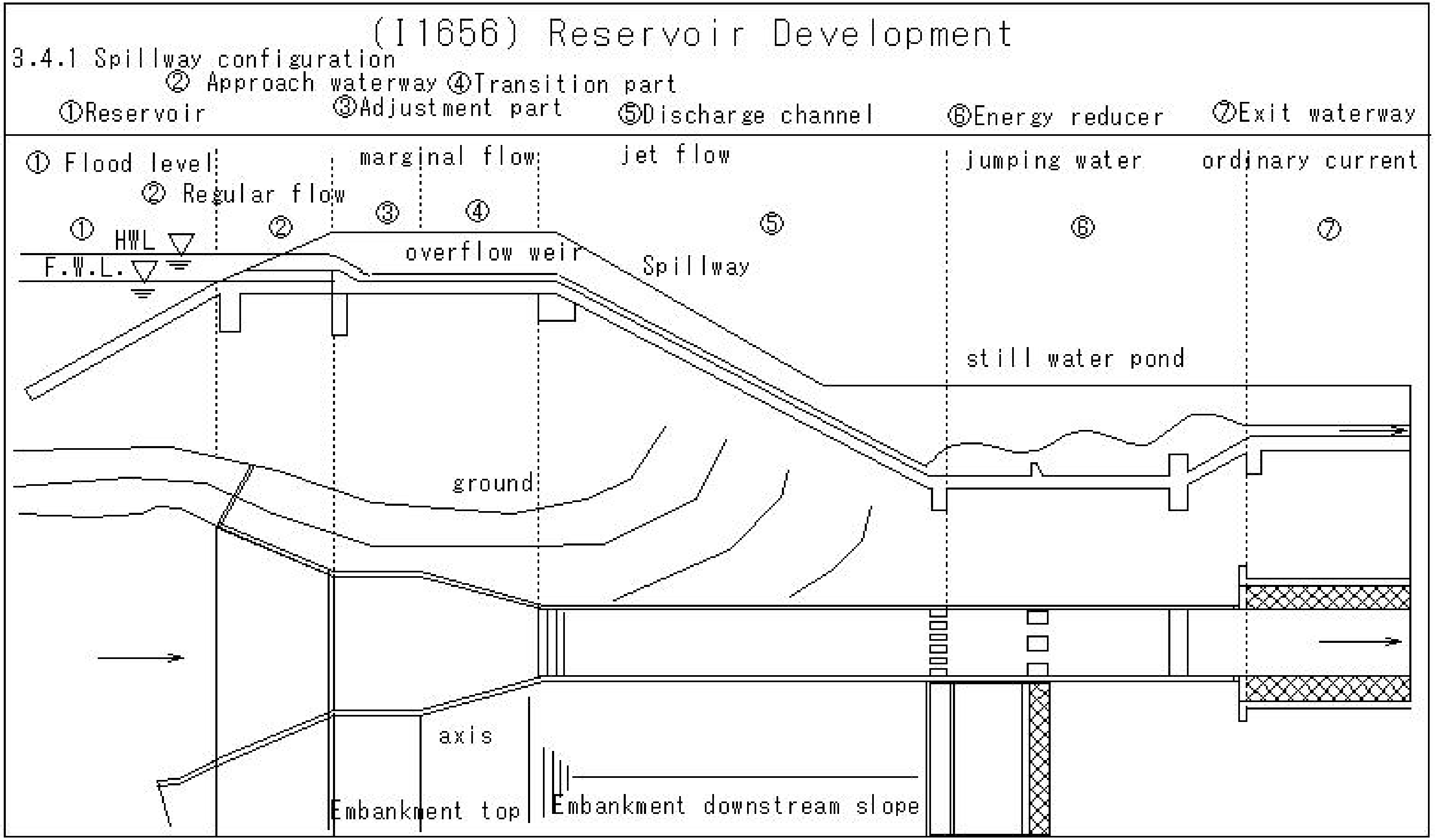
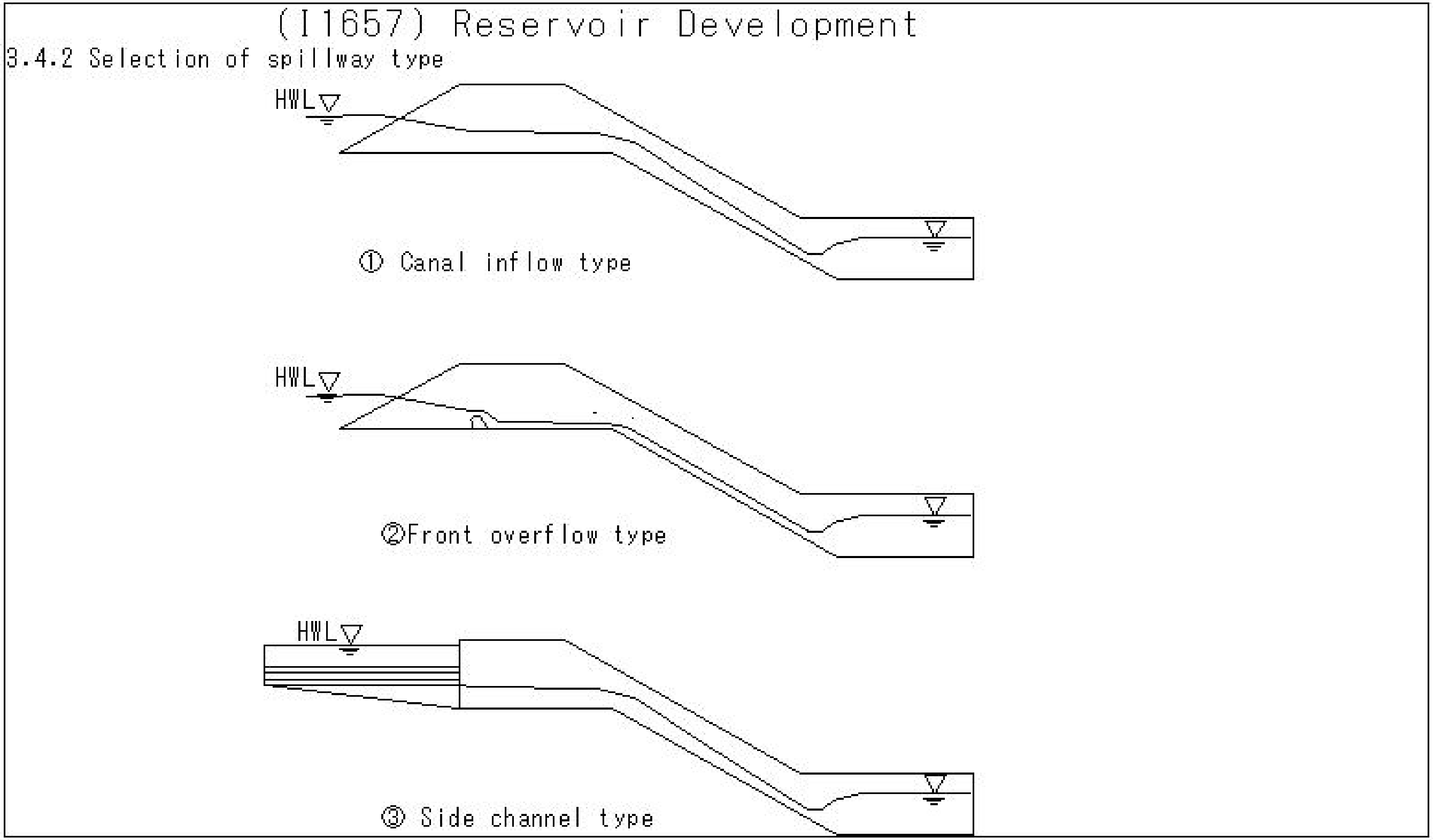


Figure-3.3.20 Upstream slope protection works

(I1656) Reservoir Development



(I1657) Reservoir Development



(I1658) Reservoir Development
3.4.2 Selection of spillway type
Table-3.4.1 Comparison of spillway types

① Spillway type	② Part type		⑤ Comparison of each spillway type		
	③Adjustment part	④Transition part	⑥ Spillway location	⑦Flood volume	⑧ Flood drainage capacity
① Canal inflow type	Waterway inflow type	Front overflow	On the ground or on the	Extremely small	Small
②Front overflow type	Overflow type	condensing waterway	On the ground or on the	Small to middle school	About 1.5 times that of the canal
③ Side channel type	Overflow type	side channel	On the ground	medium to large	About 1.5 times that of the canal

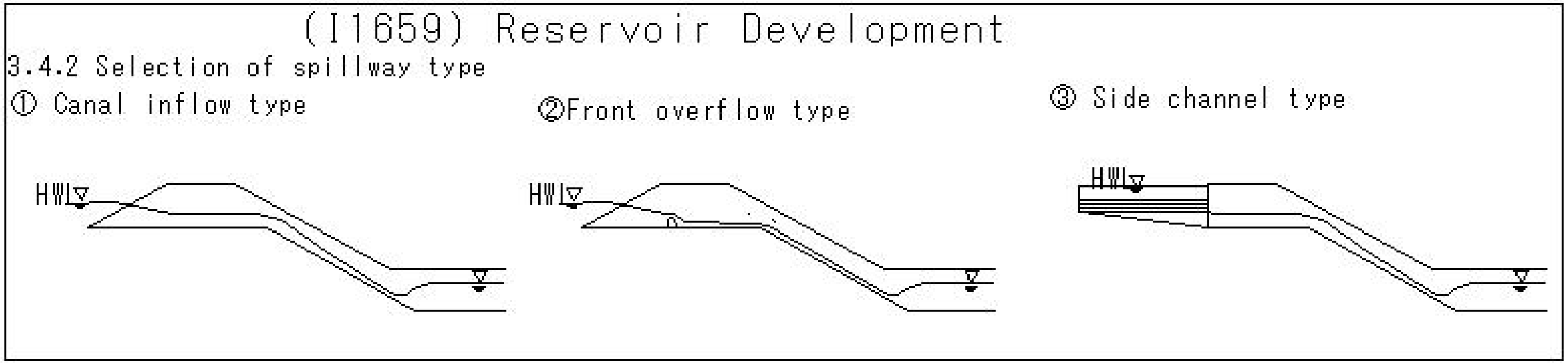
(I1659) Reservoir Development

(I1659) Reservoir Development

3.4.2 Selection of spillway type

Table-3.4.1 Comparison of spillway types

① Spillway type	② Part type		⑤ Comparison of each spillway type		
	③Adjustment part	④Transition part	⑥ Spillway location	⑦Flood volume	⑧ Flood drainage capacity
① Canal inflow type	Waterway inflow type	Front overflow	On the ground or on the	Extremely small	Small
②Front overflow type	Overflow type	condensing waterway	On the ground or on the	Small to middle school	About 1.5 times that of the canal
③ Side channel type	Overflow type	side channel	On the ground	medium to large	About 1.5 times that of the canal



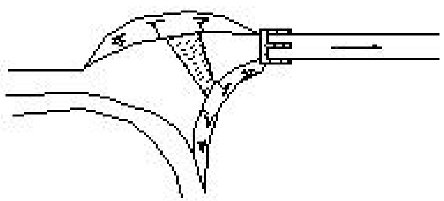
(I1660) Reservoir Development

Spillway

(I1660) Reservoir Development

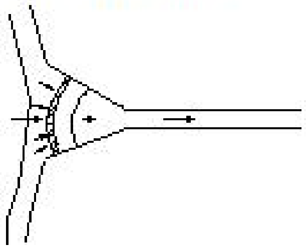
FiguFigure 3.4.3 Example of inlet designre

①Chute type



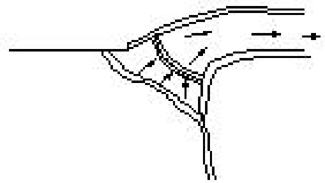
163

②Standard curve type



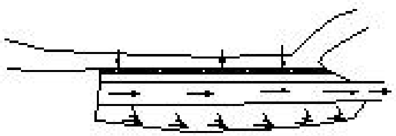
164

③Curve type



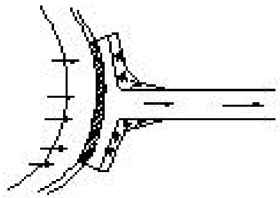
165

④Standard type side waterway



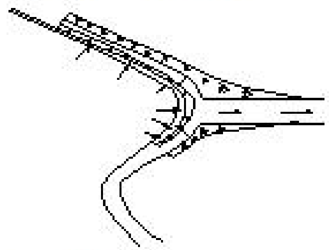
166

⑤T-shaped side waterway



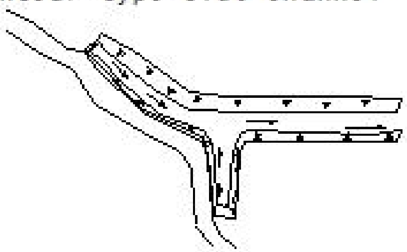
167

⑥Y-shaped side waterway



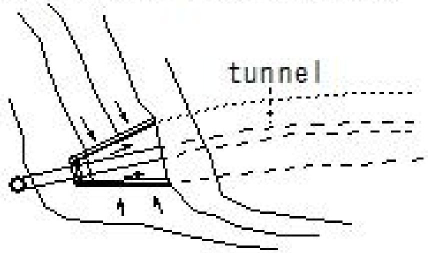
168

⑦Contour-type side channel



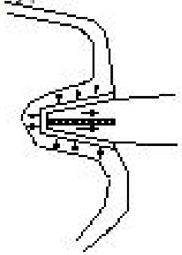
169

⑧Double type side waterway



170

⑨ Bathtub type

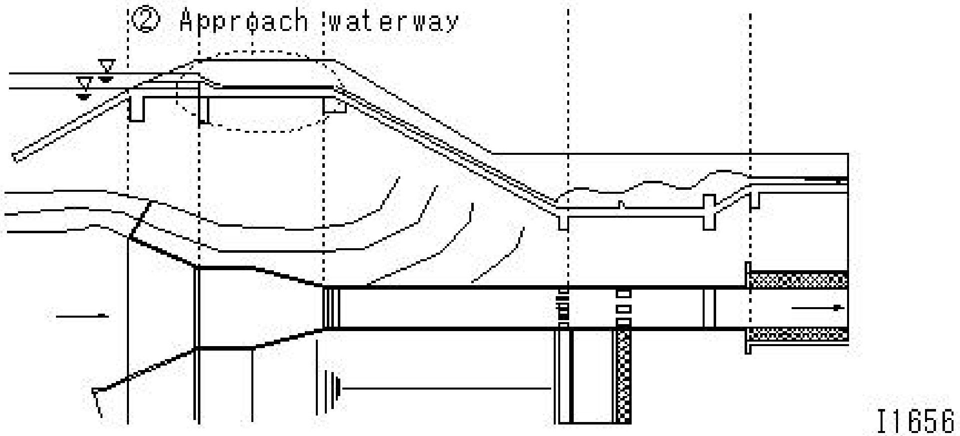


171

(I1661) Reservoir Development

3.4.3 Hydraulic design of spillway

○Approach channel



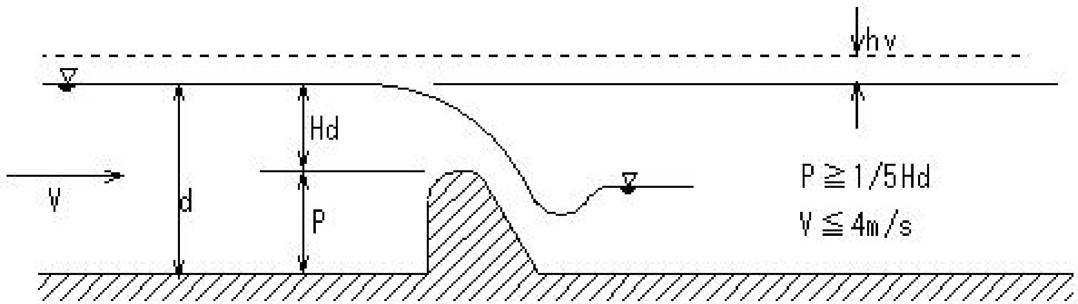
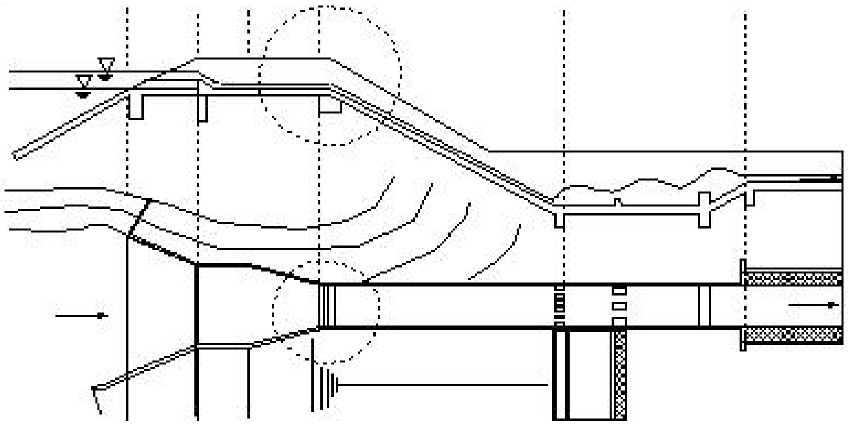


Figure 3.4.4 Spillway approach channel

(I1662) Reservoir Development

(I1662) Reservoir Development

3.4.3 Hydraulic design of spillway



I1656

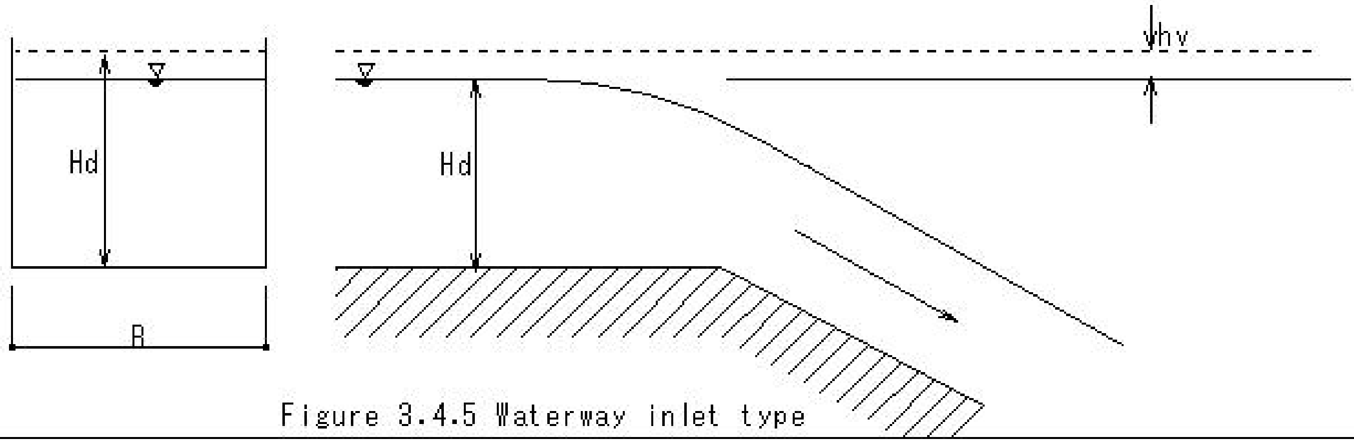


Figure 3.4.5 Waterway inlet type

(I1663) Reservoir Development

(I1663) Reservoir Development

3.4.3 Hydraulic design of spillway

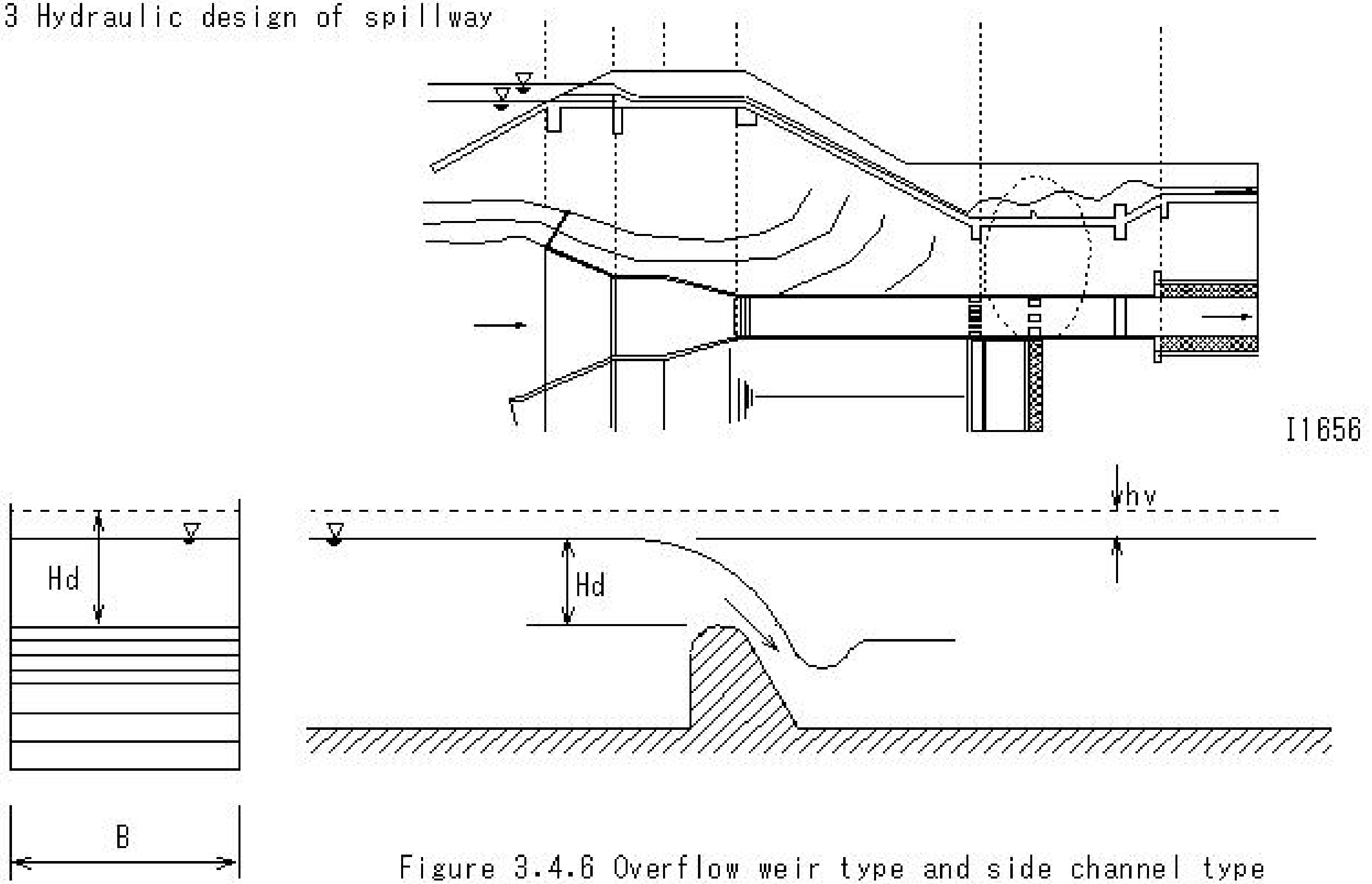


Figure 3.4.6 Overflow weir type and side channel type

(I1664) Reservoir Development

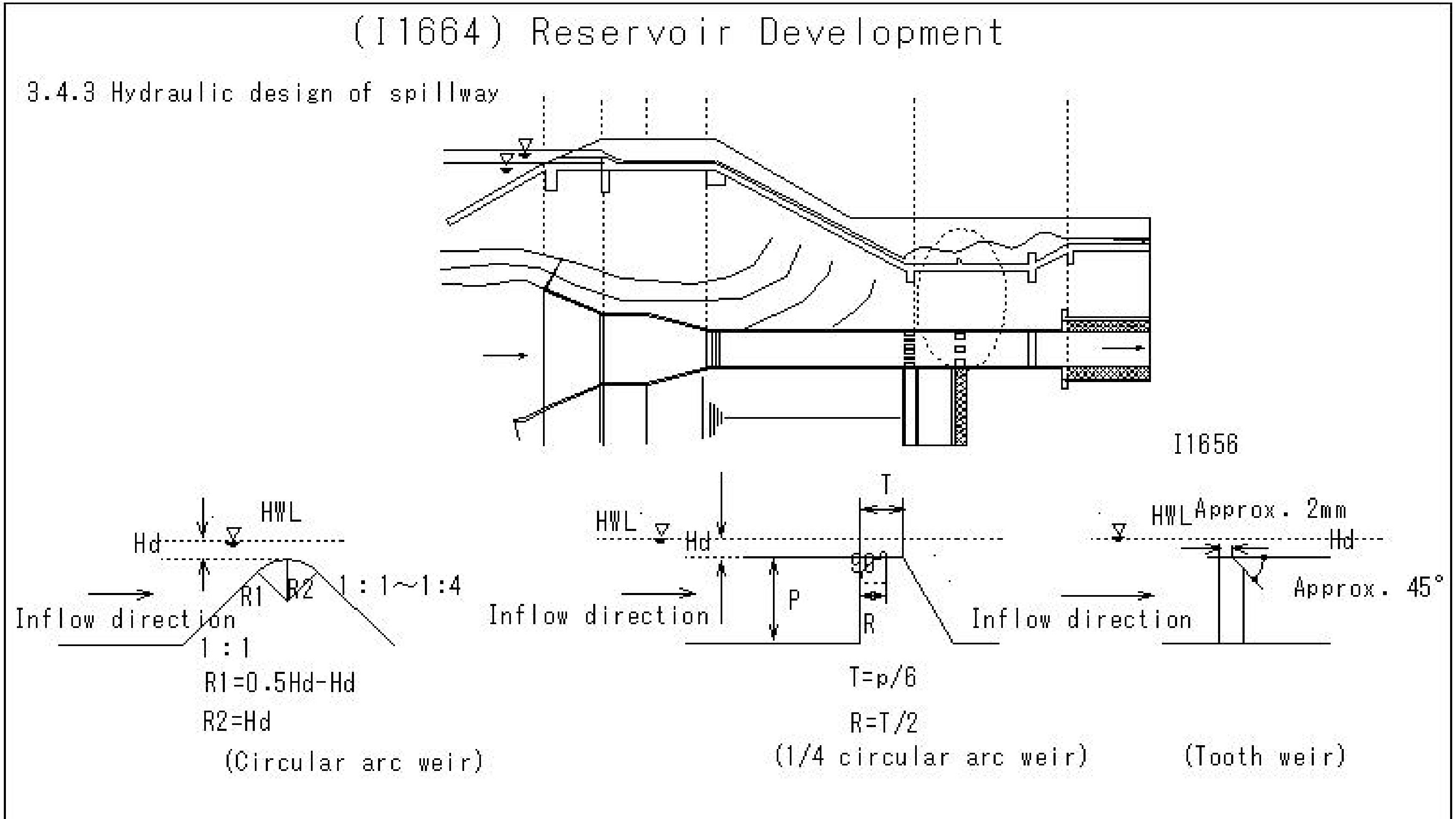


Figure 3.4.10 Cross-sectional shape of a simple overflow weir

(I1665) Reservoir Development

(I1665) Reservoir Development

3.4.3 Hydraulic design of spillway

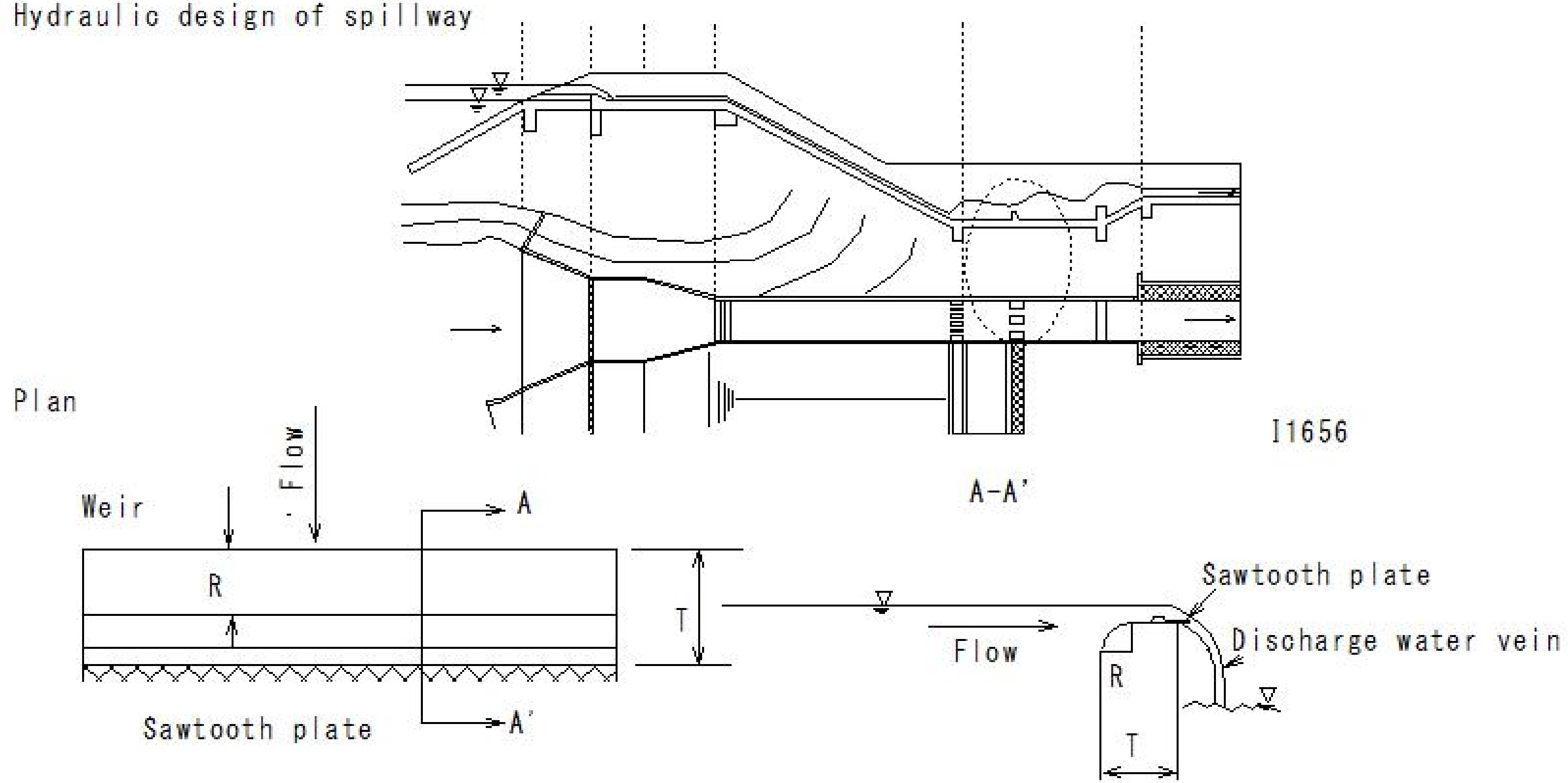


Figure 3.4.11 Suppression of water film vibration (noise) at low overflow head by sawtooth plate

(I1666) Reservoir Development

(I1666) Reservoir Development

3.4.3 Hydraulic design of spillway

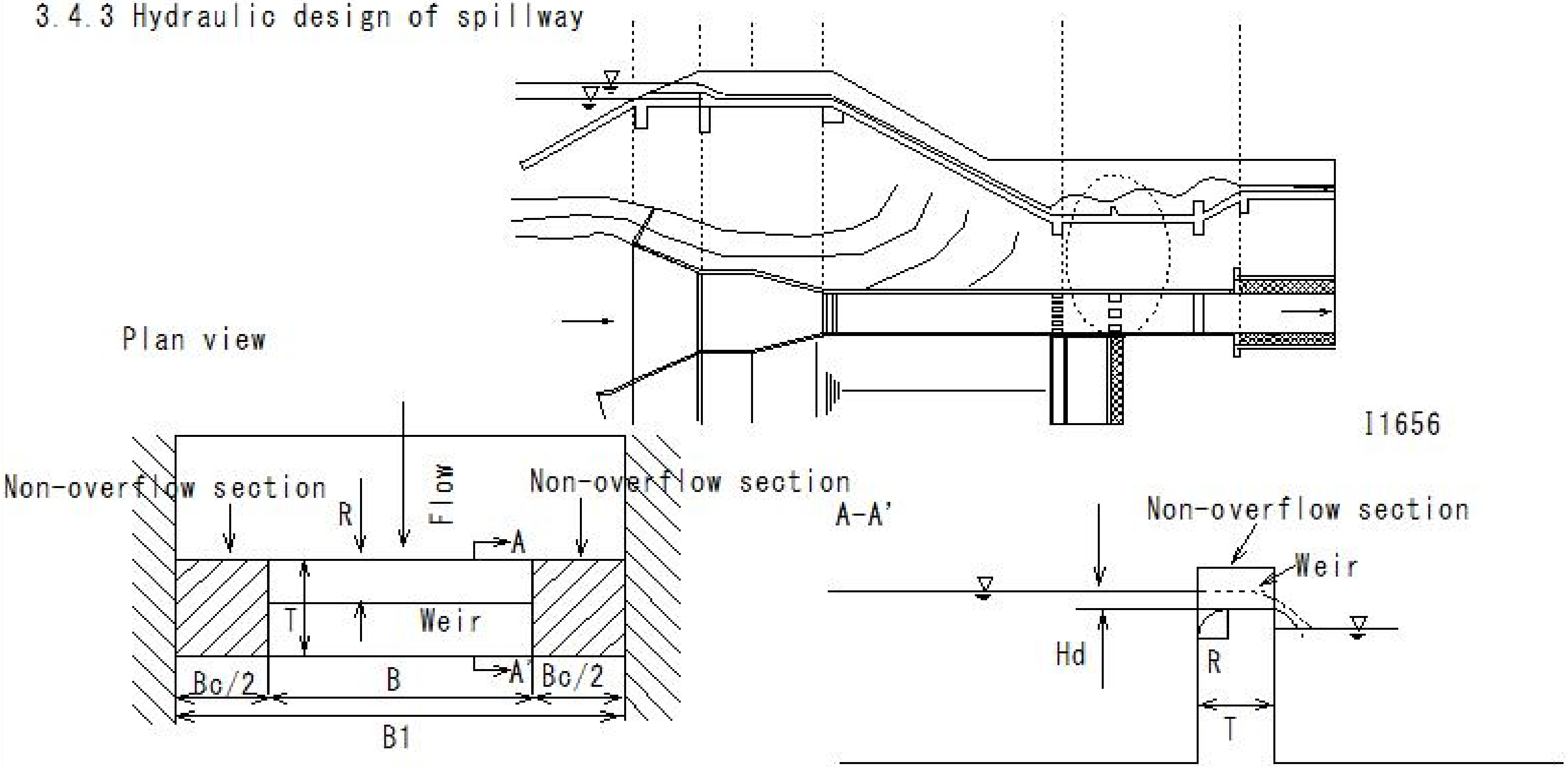


Figure 3.4.12 Example of a non-overflow wall

(I1667) Reservoir Development

(I1667) Reservoir Development

3.4.3 Hydraulic design of spillway

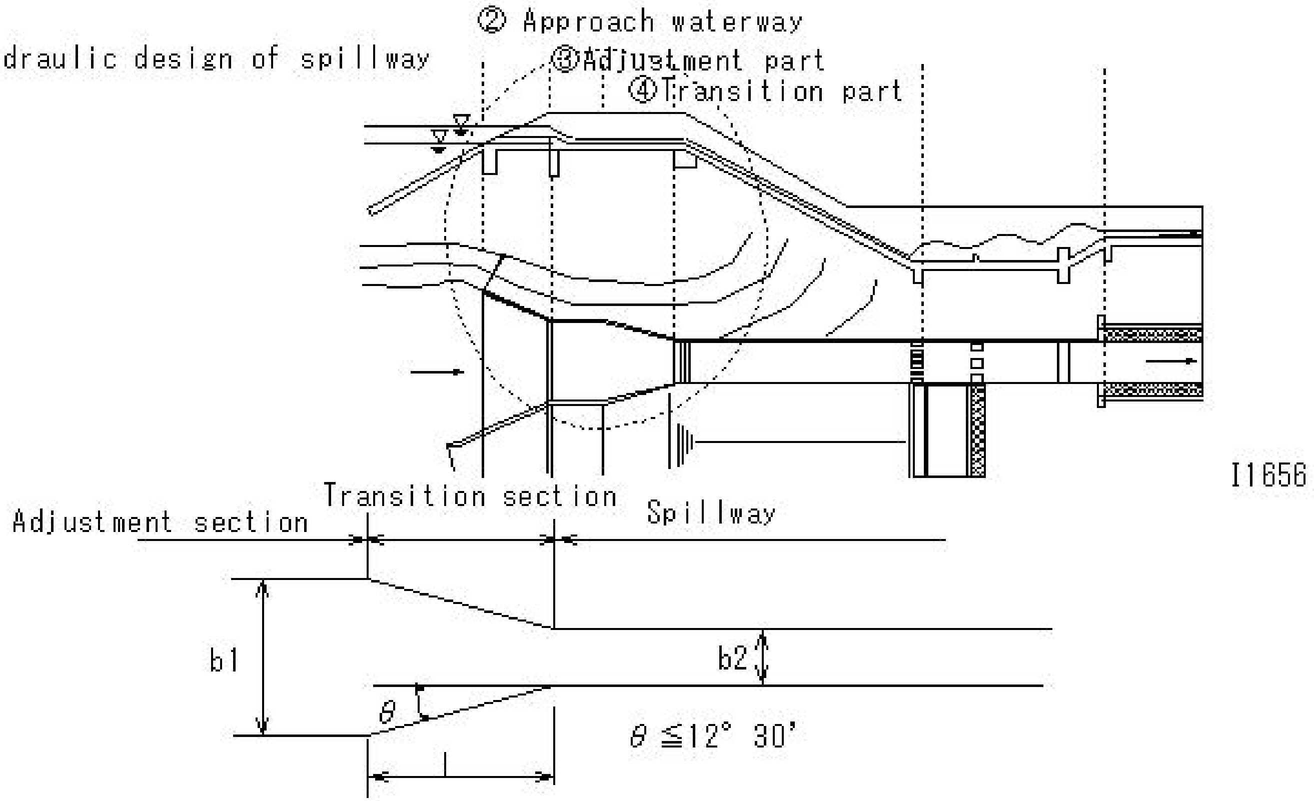
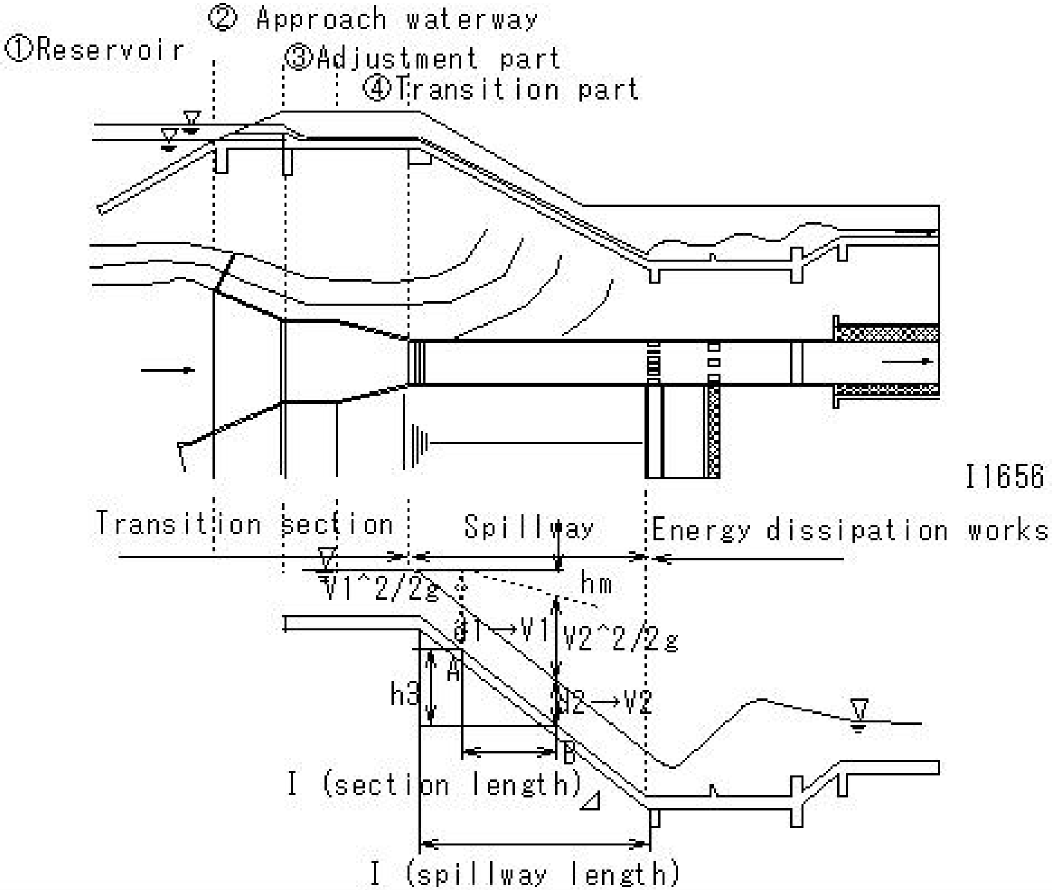


Figure 3.4.13 Plan shape of the transition section (contraction shape)

(I1668) Reservoir Development

(I1668) Reservoir Development

3.4.3 Hydraulic design of spillway



(I1669) Reservoir Development

3.4.3 Hydraulic design of spillway

Energy dissipation works

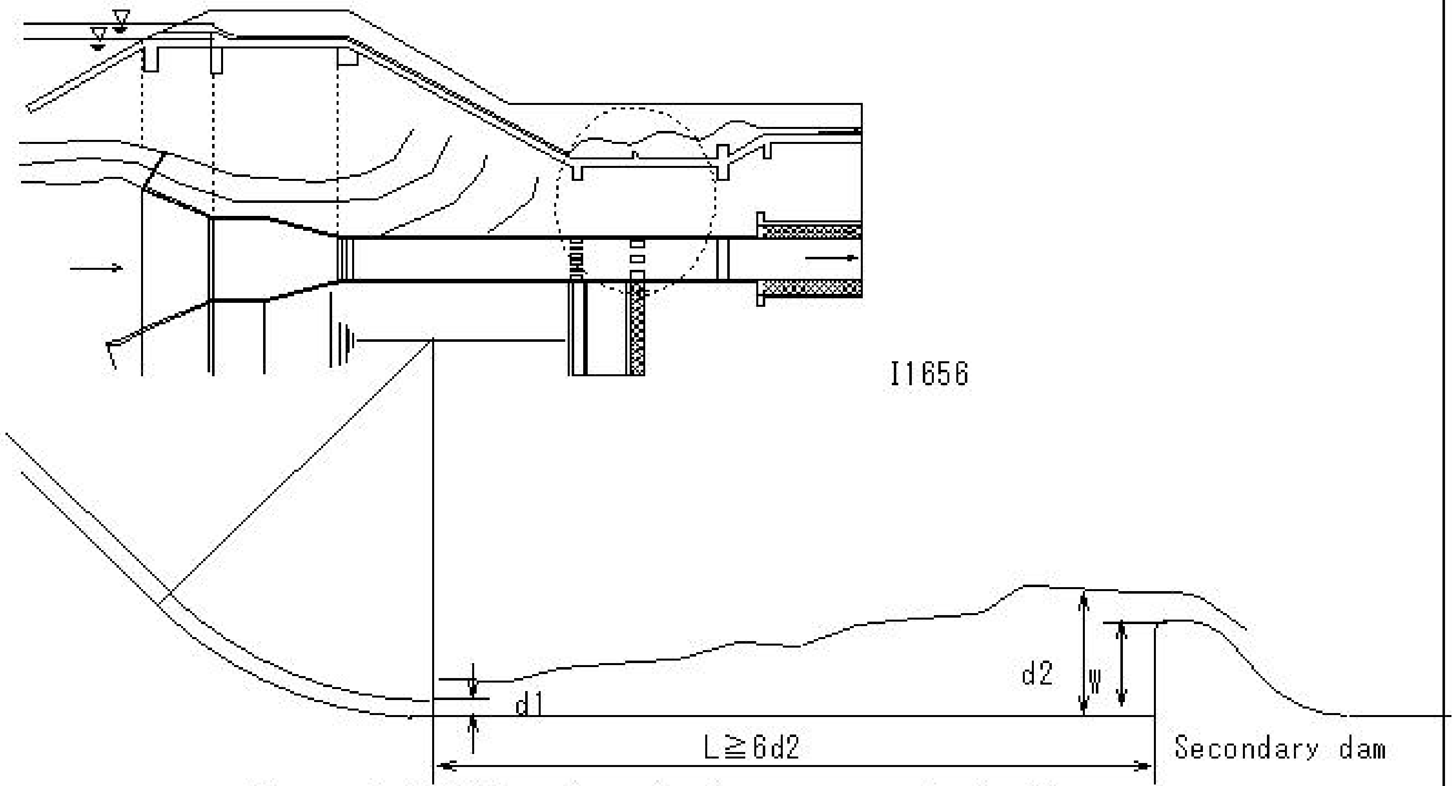
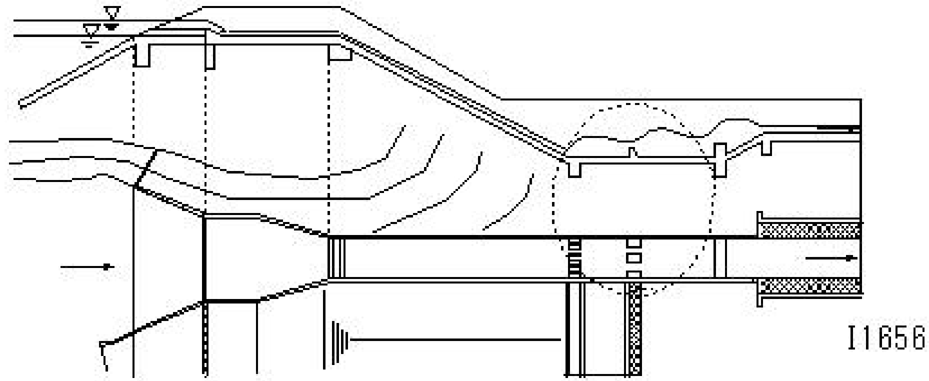


Figure 3.4.20 Secondary dam type energy dissipation works

(I1670) Reservoir Development

3.4.3 Hydraulic design of spillway

Energy dissipation works



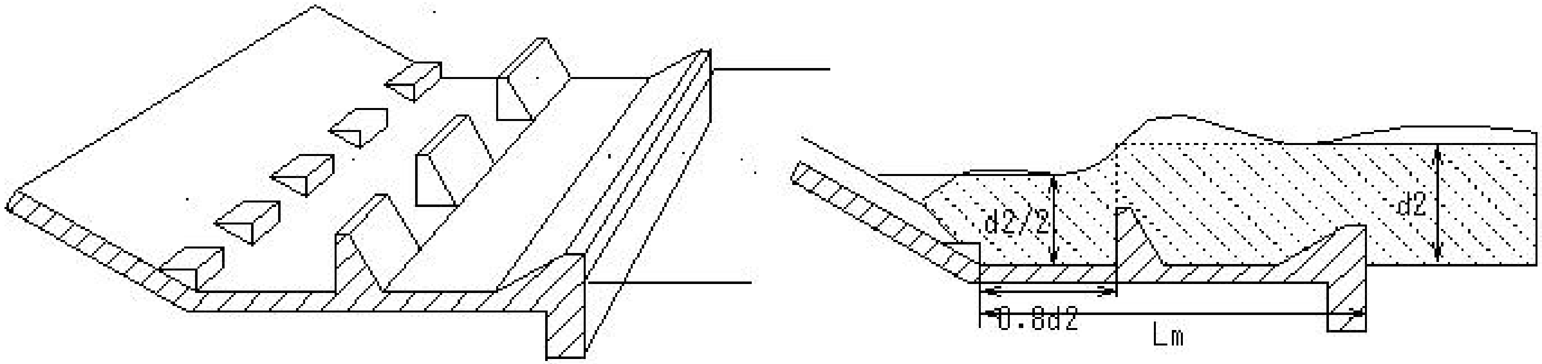


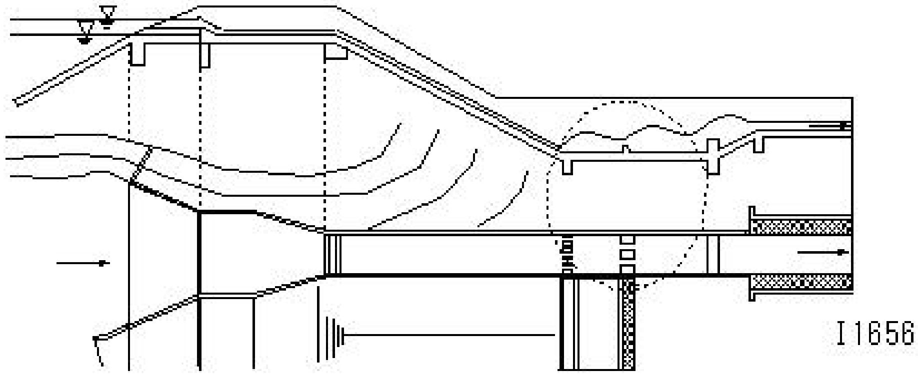
Figure-3.4.21 Type III still water land

(I1671) Reservoir Development

(I1671) Reservoir Development

3.4.3 Hydraulic design of spillway

Energy dissipation works



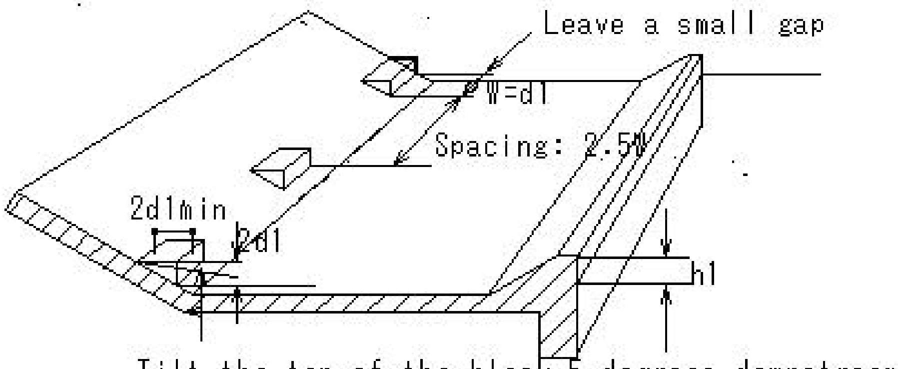


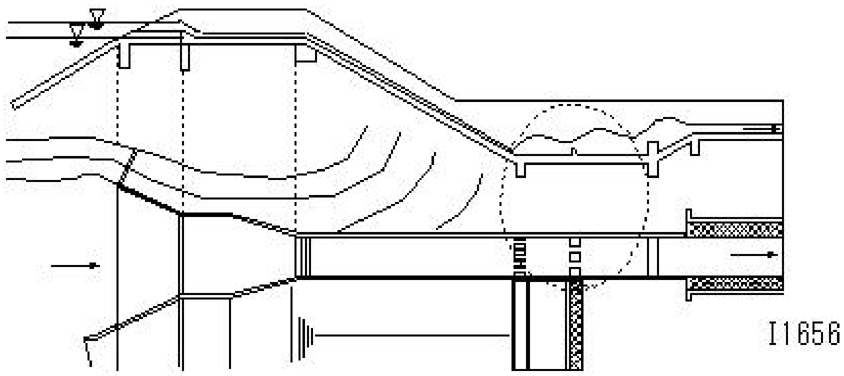
Figure 3.4.23 Type IV still water area

(I1672) Reservoir Development

(I1672) Reservoir Development

3.4.3 Hydraulic design of spillway

Drop-type energy dissipator



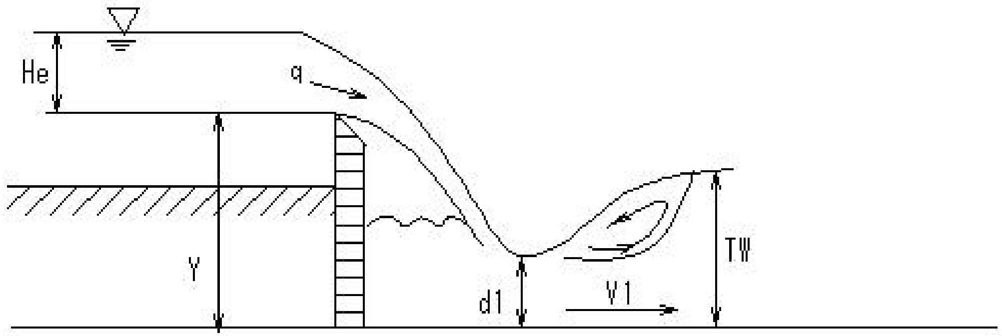
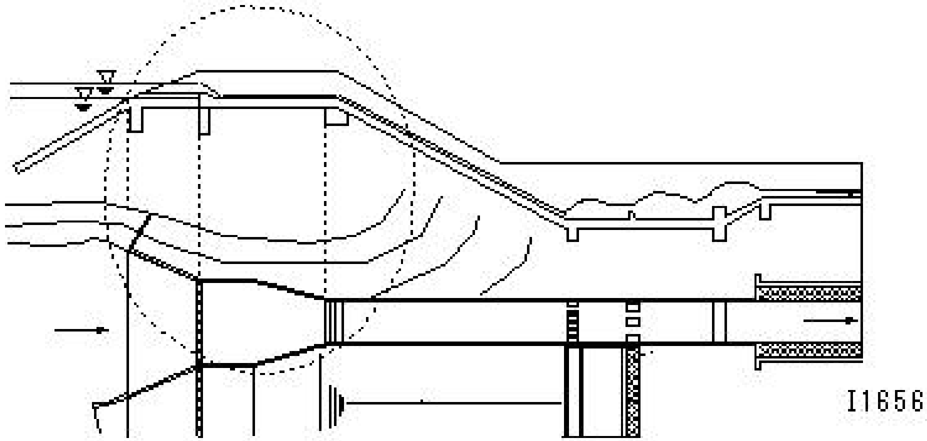


Figure 3.4.26 Drop-type energy dissipator

(I1673) Reservoir Development

(I1673) Reservoir Development

3.4.3 Hydraulic design of spillway



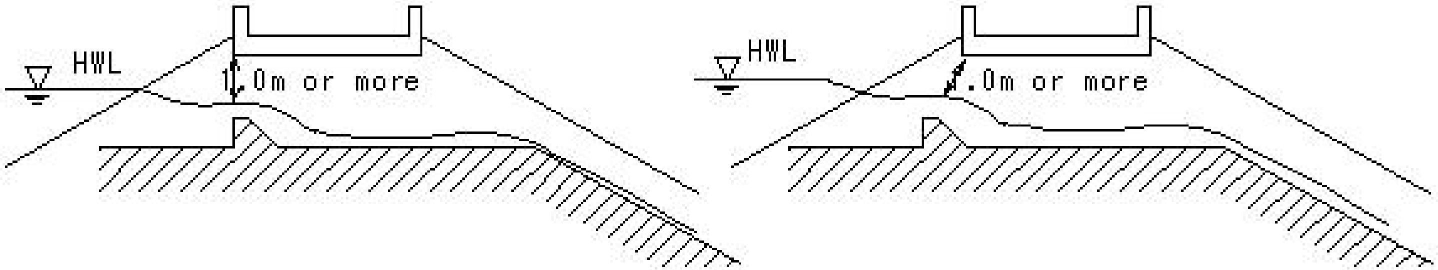


Figure 3.4.31 Clearance under managed bridge

(I1674) Reservoir Development

(I1674) Reservoir Development

3.4.3 Hydraulic design of spillway

Joints

Figure 3.4.44 Joint construction

①Expansion joints

②Contraction joints

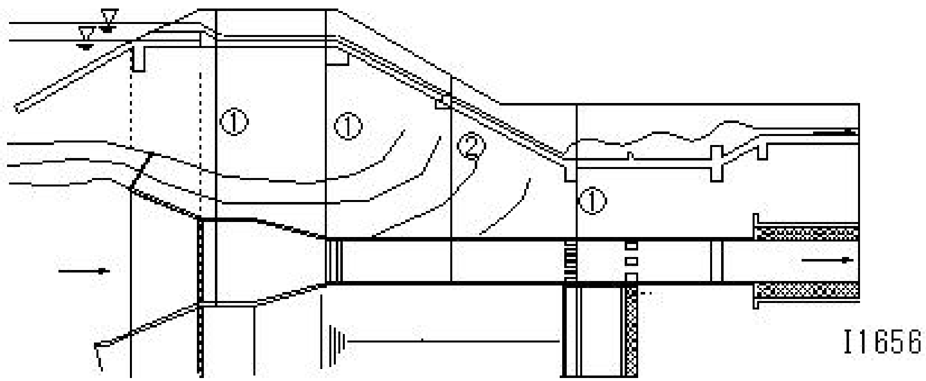


Figure 3.4.44 Joint construction

(I1675) Reservoir Development

(I1675) Reservoir Development

3.4.3 Hydraulic design of spillway

Joints

Figure 3.4.44 Joint construction

①Expansion joints

②Contraction joints

Figure 3.4.45 Contraction/expansion joint

①Expansion joint

②Contraction joint

③Waterstop

④Dowel bar

⑤Apply oil-based paint to prevent adhesion

⑥Joint material

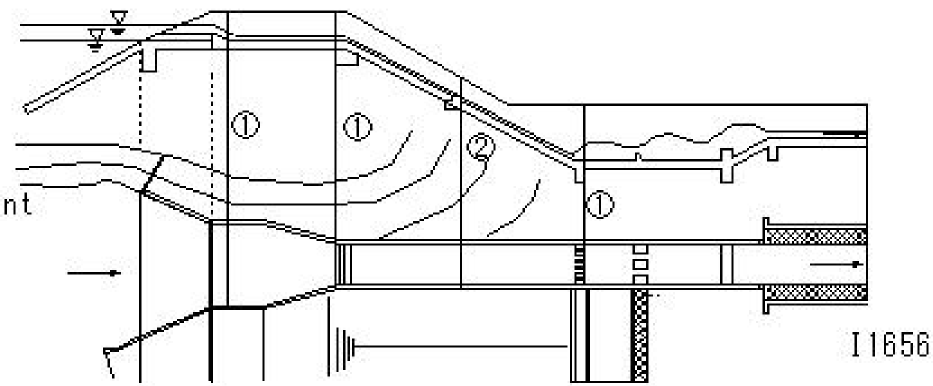


Figure 3.4.44 Joint construction

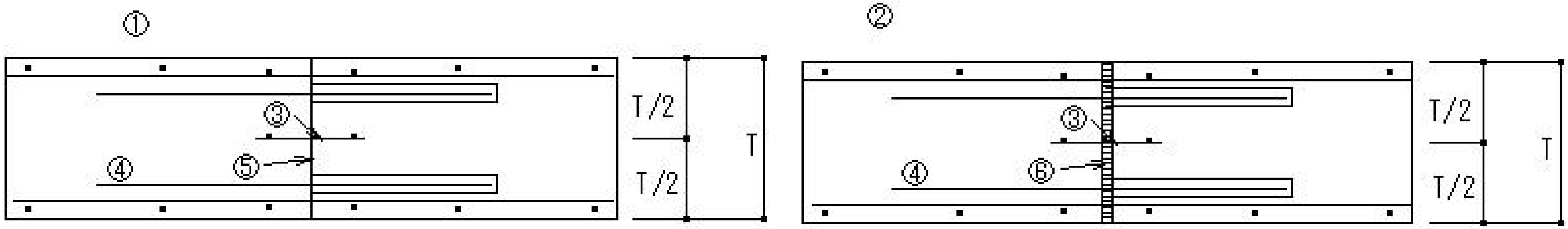


Figure 3.4.45 Contraction/expansion joint

(I1676) Reservoir Development

(I1676) Reservoir Development

3.4.3 Hydraulic design of spillway

Joints

Figure 3.4.44 Joint construction

①Expansion joints

②Contraction joints

Figure 3.4.45 Contraction/expansion joint

①Expansion joint

②Contraction joint

③Waterstop

④Dowel bar

⑤Apply oil-based paint to prevent adhesion

⑥Joint material

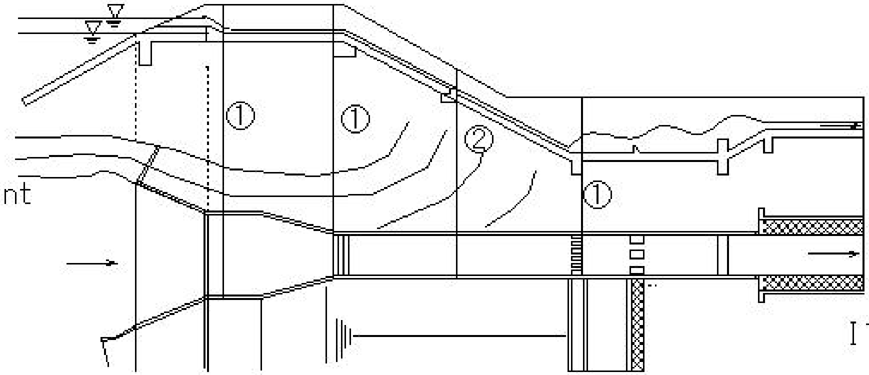


Figure 3.4.44 Joint construction

Figure 3.4.45 Contraction/expansion joint

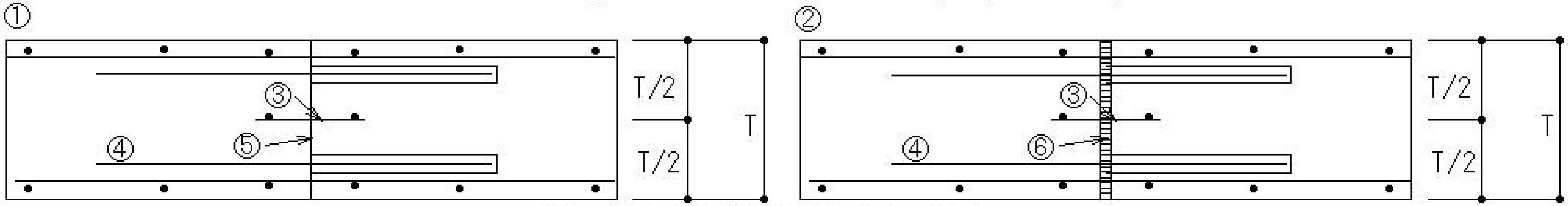


Table 3.4.11 Width of waterstop

Concrete thickness (mm)	Waterstop width
200 or less	150－230
200-300	200-250
300-400	230-300
400 or more	Over 300

(I1677) Reservoir Development

3.4.3 Hydraulic design of spillway

Spillway/Still water area: When there is spring water from the ground

Side drain/Under drain

① Weep hole (for bottom plate)

② Under drain

③ Filter

④ Side drain

⑤ Weep hole

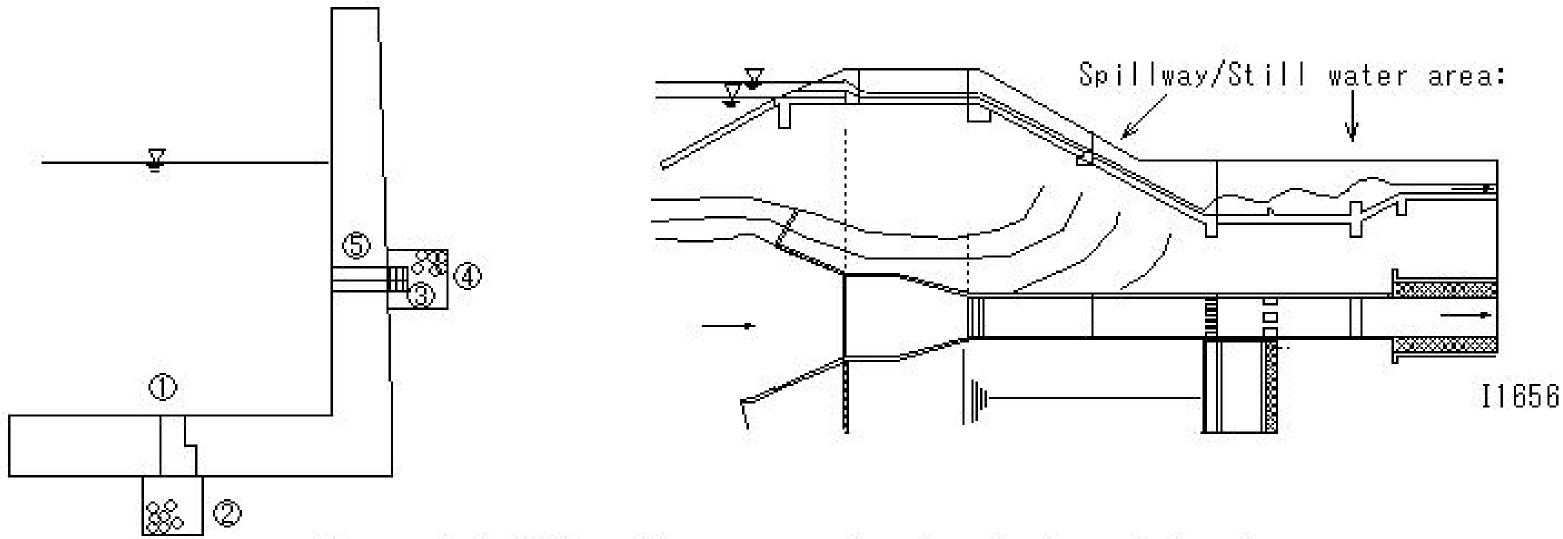


Figure 3.4.47 Installation example of side drain/under drain

(I1678) Reservoir Development

(I1678) Reservoir Development

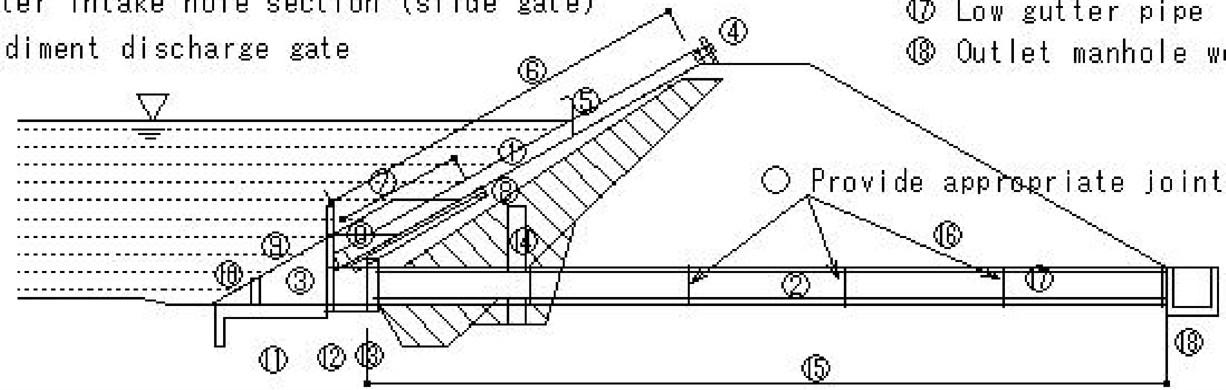
3.5.1 Configuration of water intake facilities

○ Water intake section
① Inclined pipe
② Water intake tower

○ Water conveyance section
③ Water intake tunnel
④ Bottom pipe

Water intake facility

① Inclined gutter
② Bottom gutter
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gate
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work



I1392

(I1679) Reservoir Development

(I1679) Reservoir Development

3.5.1 Configuration of water intake facilities

3.5.2 Water intake tower

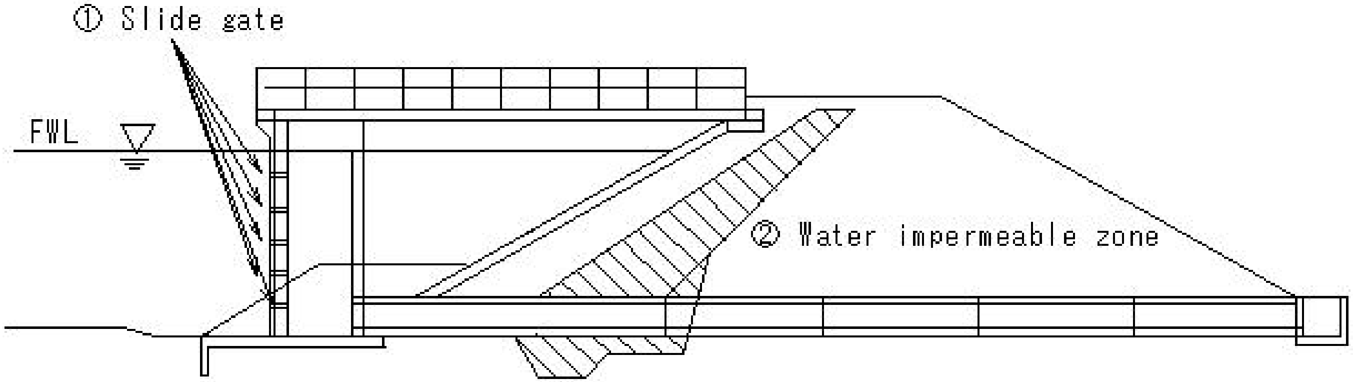


Figure 3.5.2 Water Intake Tower

I1392

(I1680) Reservoir Development

3.5.3 Bottom gutter

① Avoid filling the ground
② Decide after considering the current height of the downstream irrigation and drainage channel
③ Clay layer
④ Install a filter layer

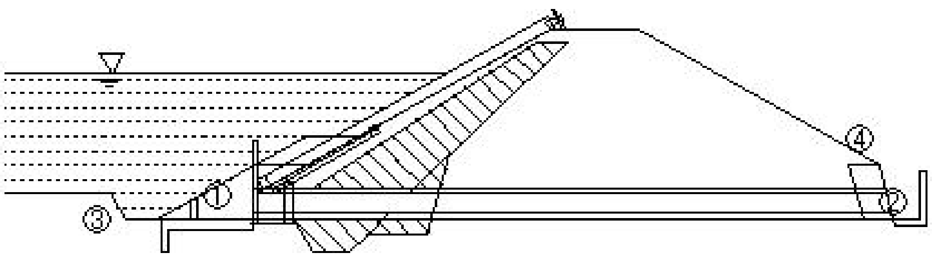


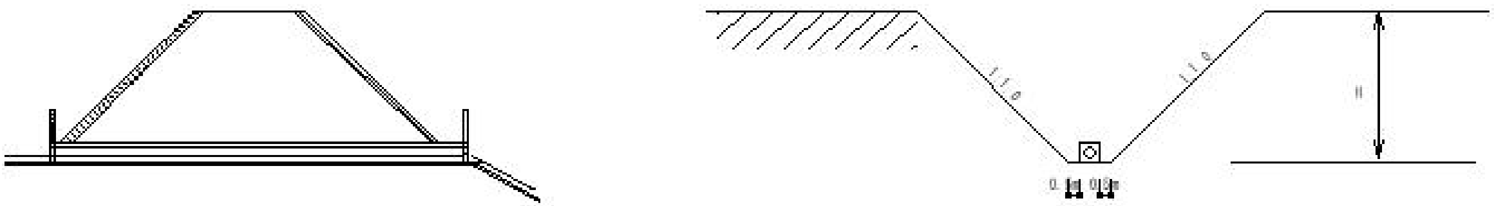
Figure 3.5.8 Foundation ground and bottom gutter longitudinal plan

(I1681) Reservoir Development

(I1681) Reservoir Development

3.5.3 Bottom trough

In case of H<5.0m



In case of H≧5.0m

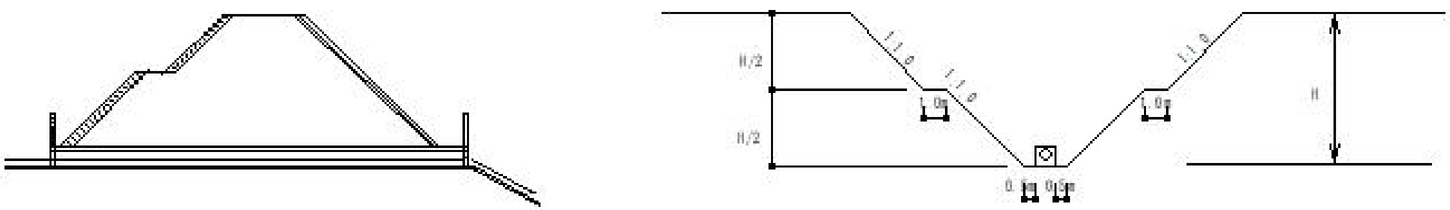


Figure 3.5.10 Cut-and-cover cross section of current embankment

(I1682) Reservoir Development

(I1682) Reservoir Development

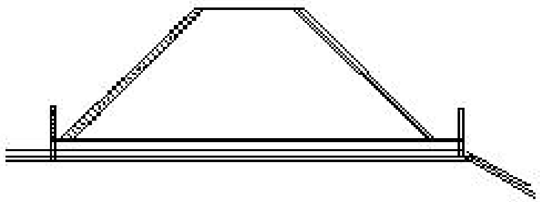
3.5.3 Bottom trough

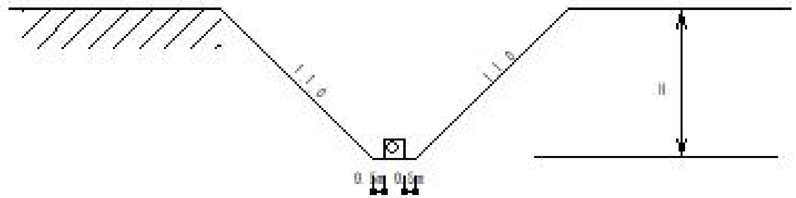
3.5.3 Bottom gutter

① Reinforced concrete 21-8-25

② Leveling concrete 18-8-25

③ D13@250





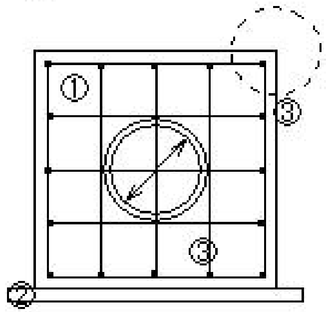


Fig. 3.5.11 Bottom gutter

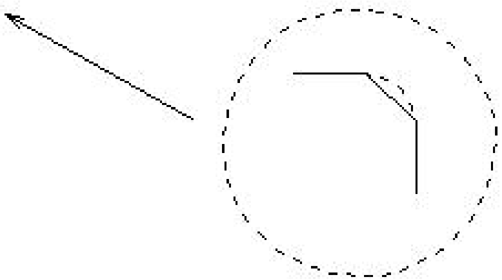


Fig. 3.5.12 Chamfering

(I1683) Reservoir Development

3.5.3 Bottom gutter

① Water-impermeable zone
② Prevention of soil particles from escaping
③ Filter
④ Perforated pipe

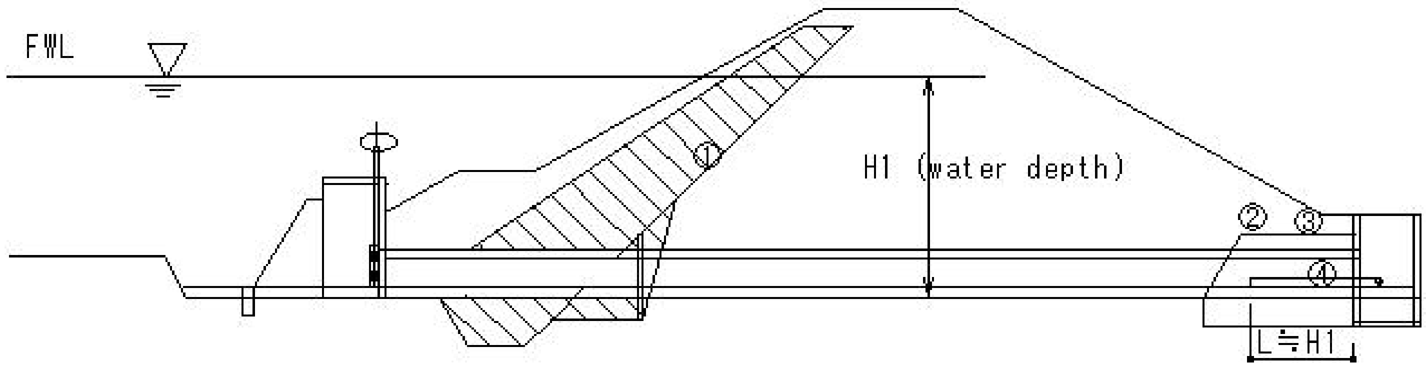


Figure 3.5.13 Downstream of the bottom culvert

(I1684) Reservoir Development

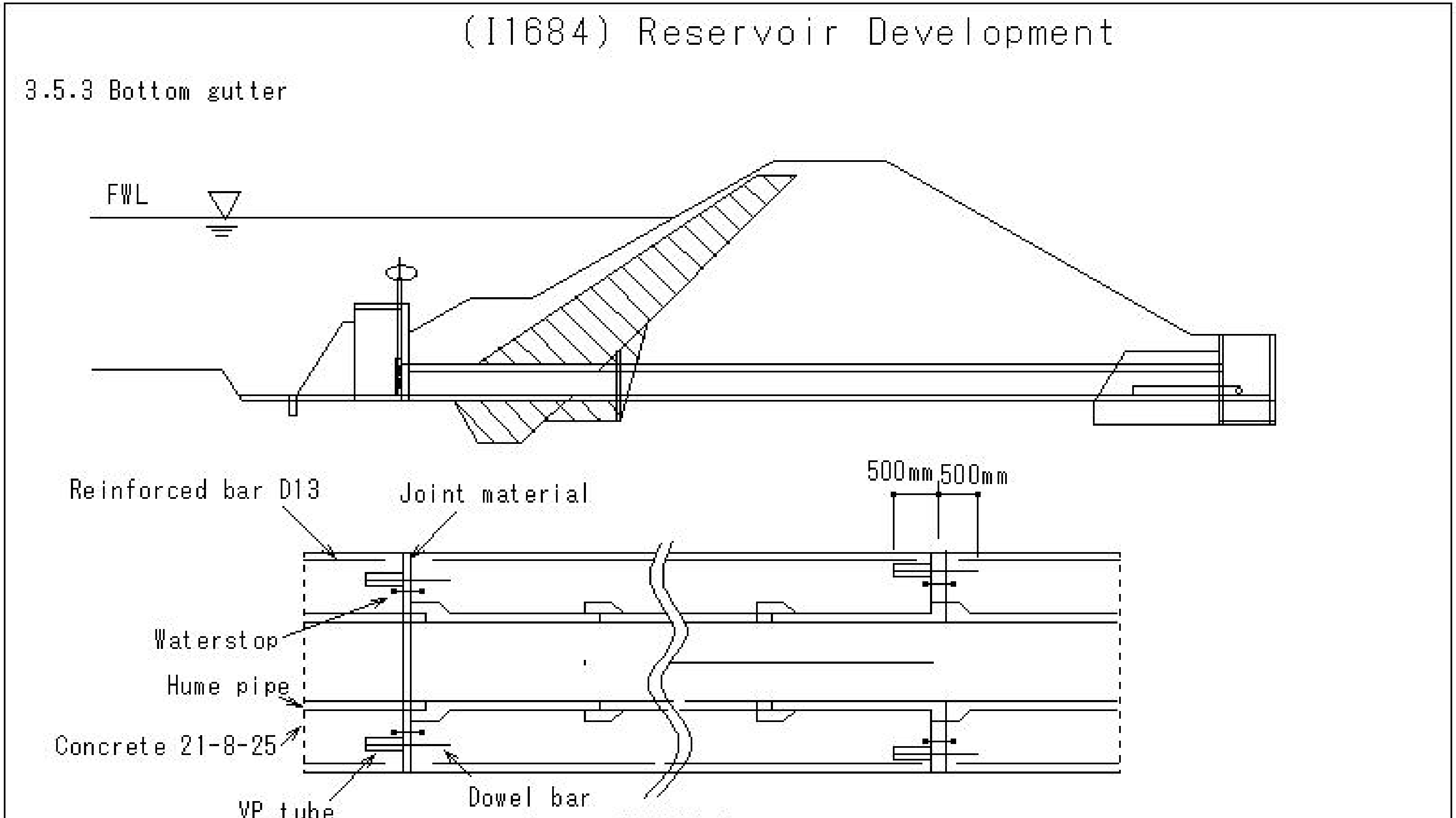


Figure 3.5.14 Bottom gutter joint

(I1685) Reservoir Development

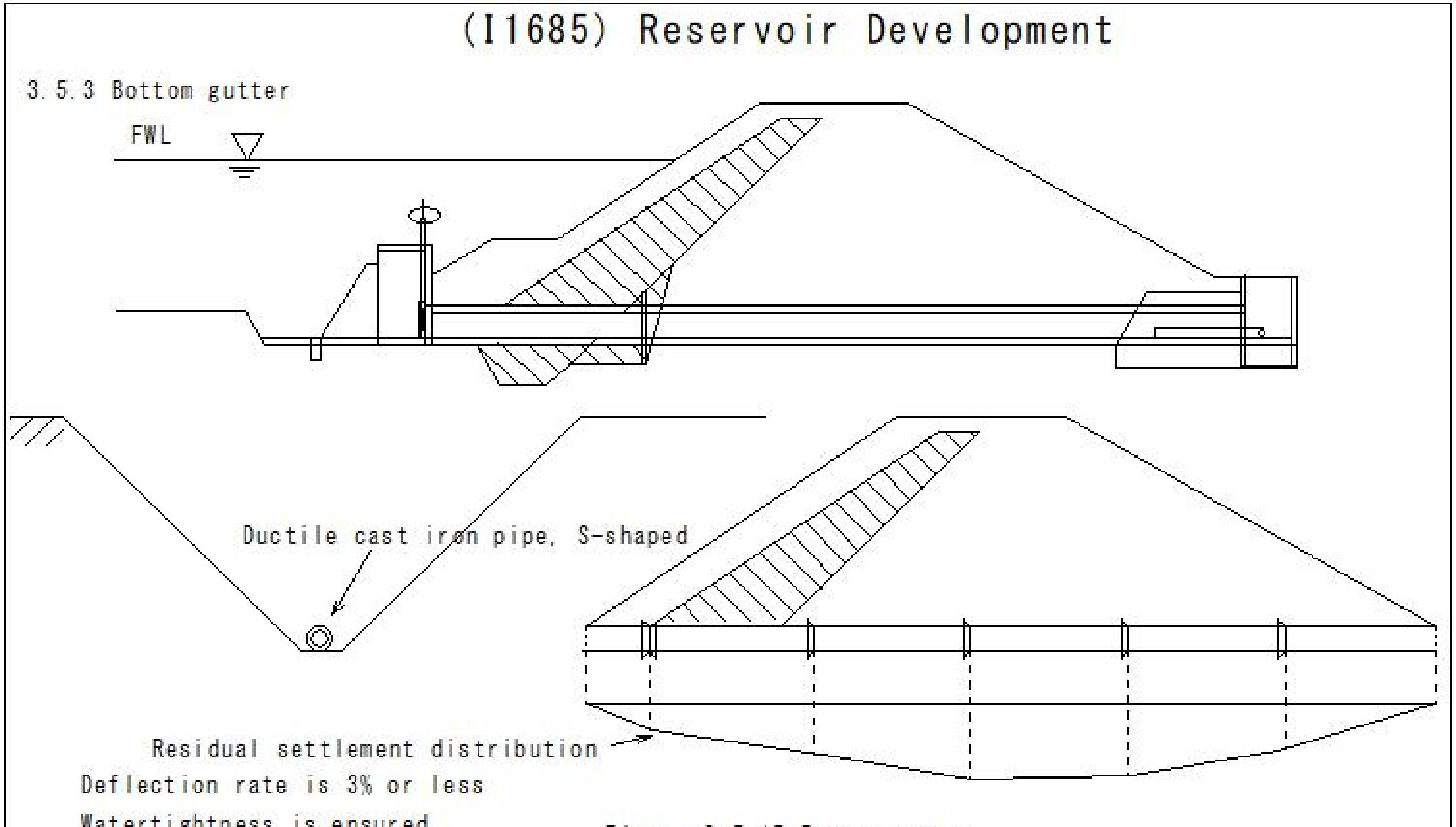


Figure 3.5.15 Bottom gutter

(I1686) Reservoir Development

(I1686) Reservoir Development

3.5.3 Bottom gutter

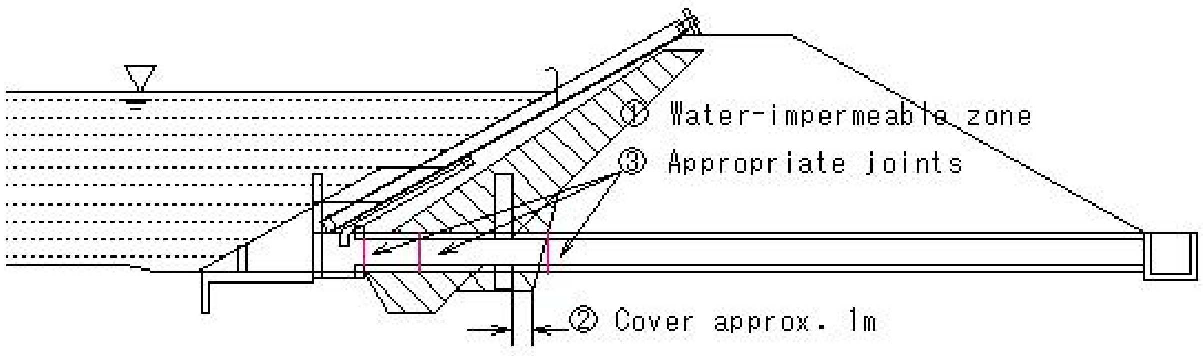


Figure 3.5.17 Location of water-stopping wall

(I1687) Reservoir Development

(I1687) Reservoir Development

3.5.3 Bottom gutter

3.5.18 Sand spit

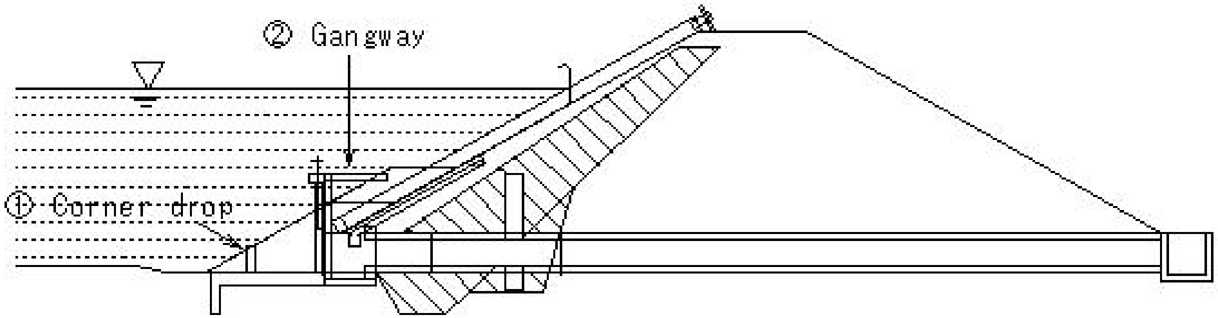


Figure 3.5.18 Sand spit

(I1688) Reservoir Development

(I1688) Reservoir Development

3.5.3 Bottom trough

Figure 3.5.19 Tip jacking method

① Excavation
② Water-impermeable zone
③ Press-in extension
④ Tip
⑤ Lead pipe
⑥ Hume pipe ϕ800mm or more
⑦ Push ring (strut)
⑧ Pressurize the soil
⑨ Hydraulic machine
⑩ Bearing wall
⑪ Jack
⑫ Grout injection hole

3.5.3 Bottom gutter

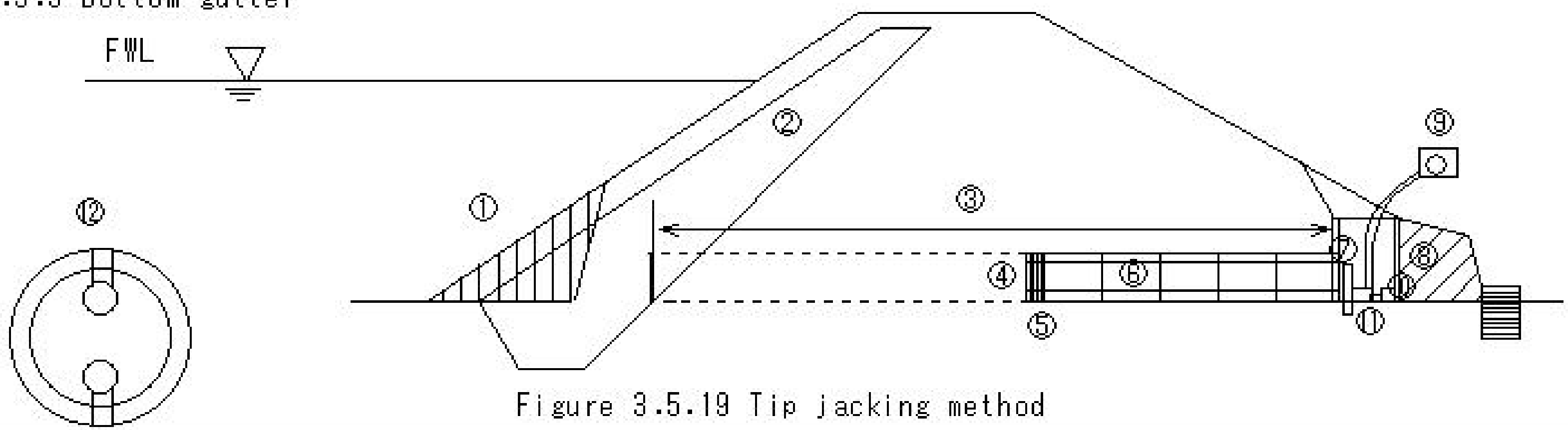


Figure 3.5.19 Tip jacking method

(I1689) Reservoir Development

3.5.3 Bottom gutter

Figure 3.5.20 Blocking of old bottom gutter

① Excavation line

② Air vent

③ Filling old bottom gutter

④ Filling material

⑤ Grout pipe

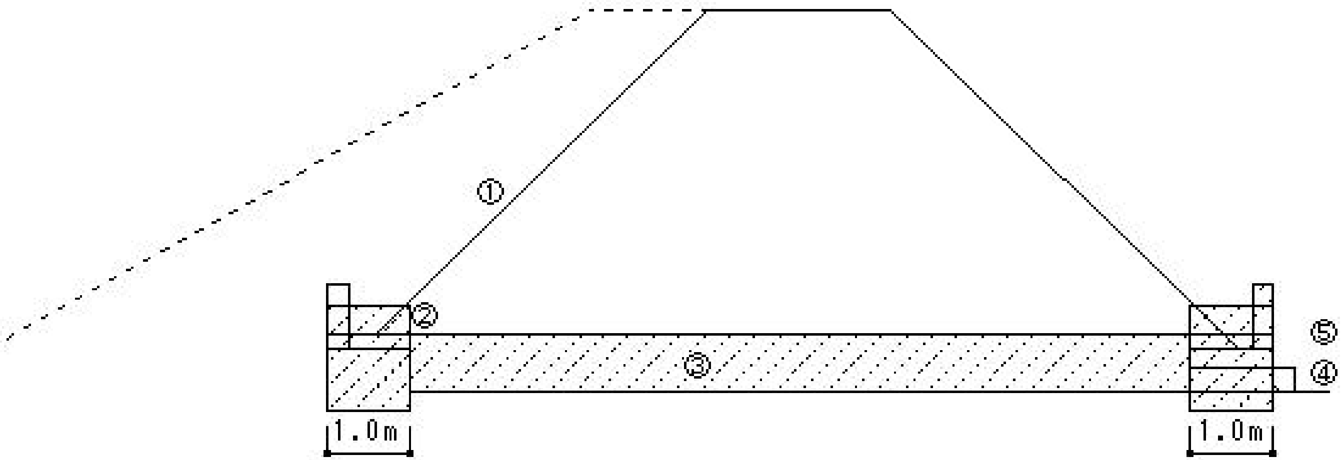


Figure 3.5.20 Blocking of old bottom gutter

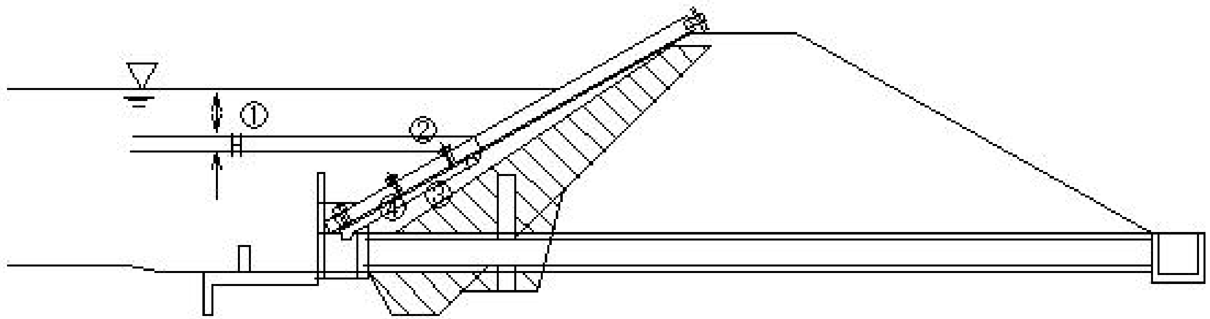
(I1690) Reservoir Development

(I1690) Reservoir Development

3.6.3 Location and structure of discharge hole

Figure 3.6.1 Water intake facility

① Emergency drop depth
② Emergency discharge hole
③ Inclined drainpipe
④ Water intake hole



Hmax = 2D or 0.3m

D: Discharge hole diameter (m)

Figure 3.6.1 Water intake facility

(I1691) Reservoir Development

(I1691) Reservoir Development

3.7.3 Seismic performance of embankment

①Elevation difference between embankment crest and full water level (FWL)

②Elevation difference between embankment crest and design flood level (HWL)

③1.0m (taking into account excess bank and freeboard)

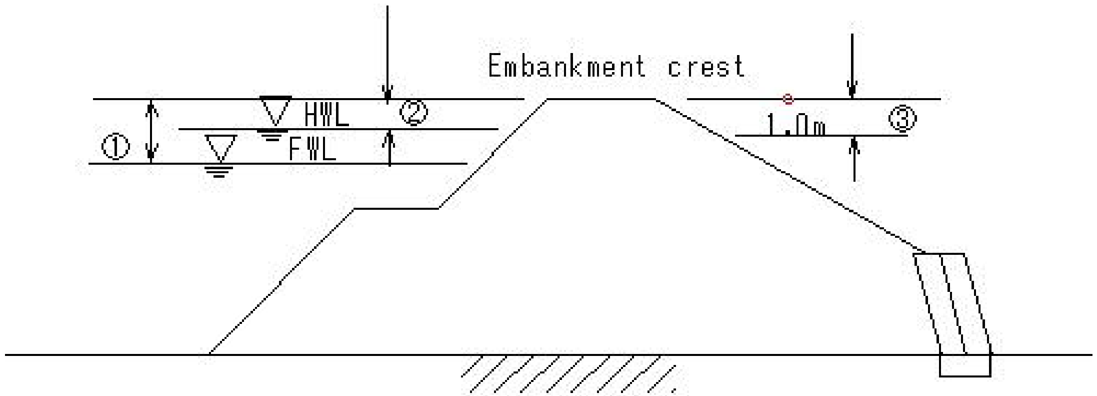


Figure 3.7.3 Allowable settlement

(I1692) Reservoir Development

4.2 Construction

Figure 4.2.1 Construction flow for reservoir construction work

① Preparation work

↓

② Temporary work (work access road, work road) → ④ Flood spillway (mainly for mountain ponds)

↓

③ Embankment excavation, floor digging

↓

⑤ (Old gutter blockage) Bottom gutter (excavation, low gutter pipe wrapping, soil discharge work, backfilling)

↓

⑥ Embankment embankment → ⑦ Flood spillway (mainly for plate ponds)

↓

⑧ Diagonal gutter (diagonal gutter pipe wrapping, gate installation)

↓

⑨ Slope protection work (upstream and downstream slopes, safety facility work)

↓

⑩ Cleaning up

(I1693) Reservoir Development

4.2 Construction

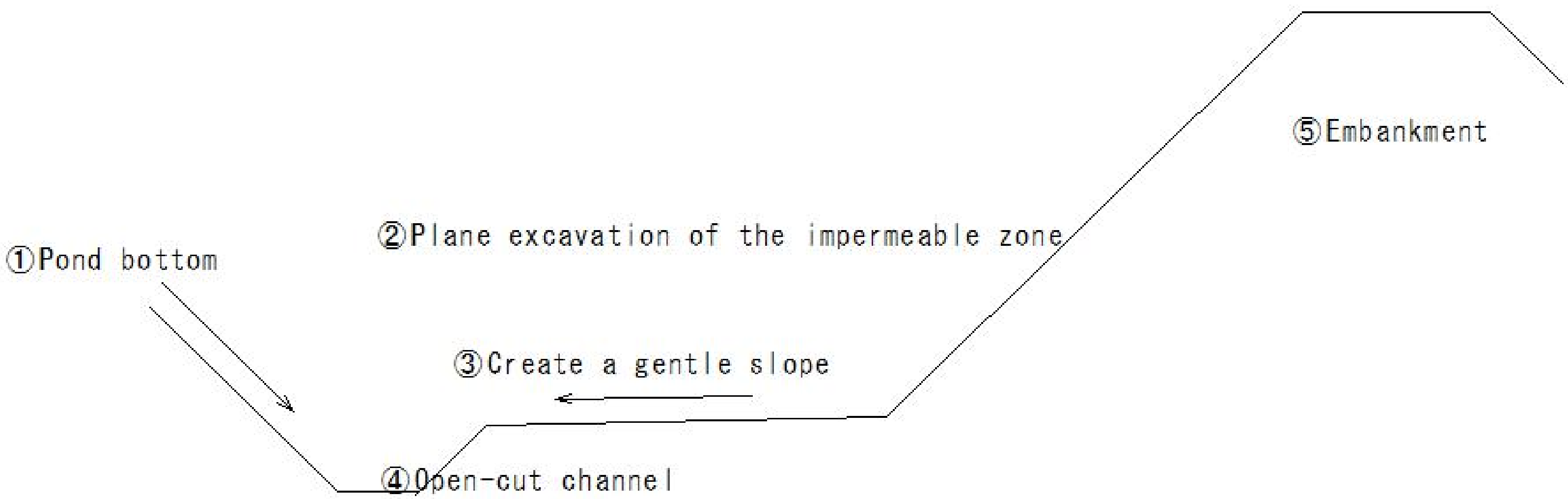


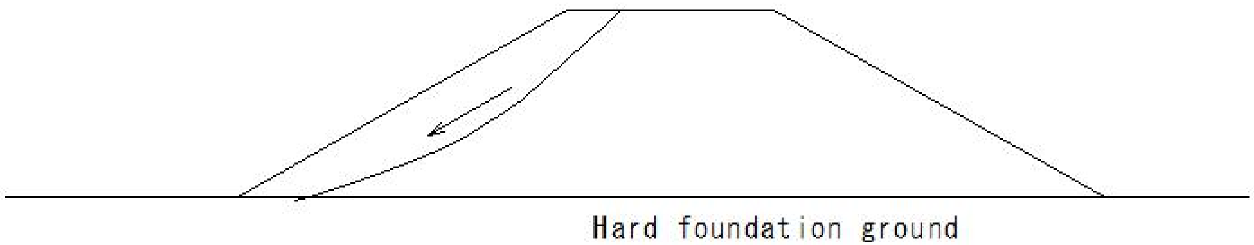
Figure-4.2.2 Drainage of the impermeable zone floor excavation

(I1694) Reservoir Development

4.2 Construction

Figure-4.2.3 Types of slope collapse

A: Slope collapse



B: Deep collapse (bottom slide)

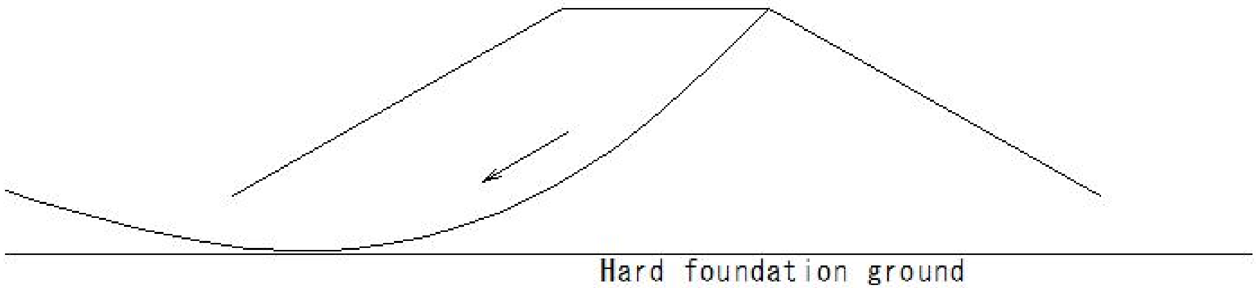


Figure-4.2.3 Types of slope collapse

(I1695) Reservoir Development

(I1695) Reservoir Development

4.2 Construction

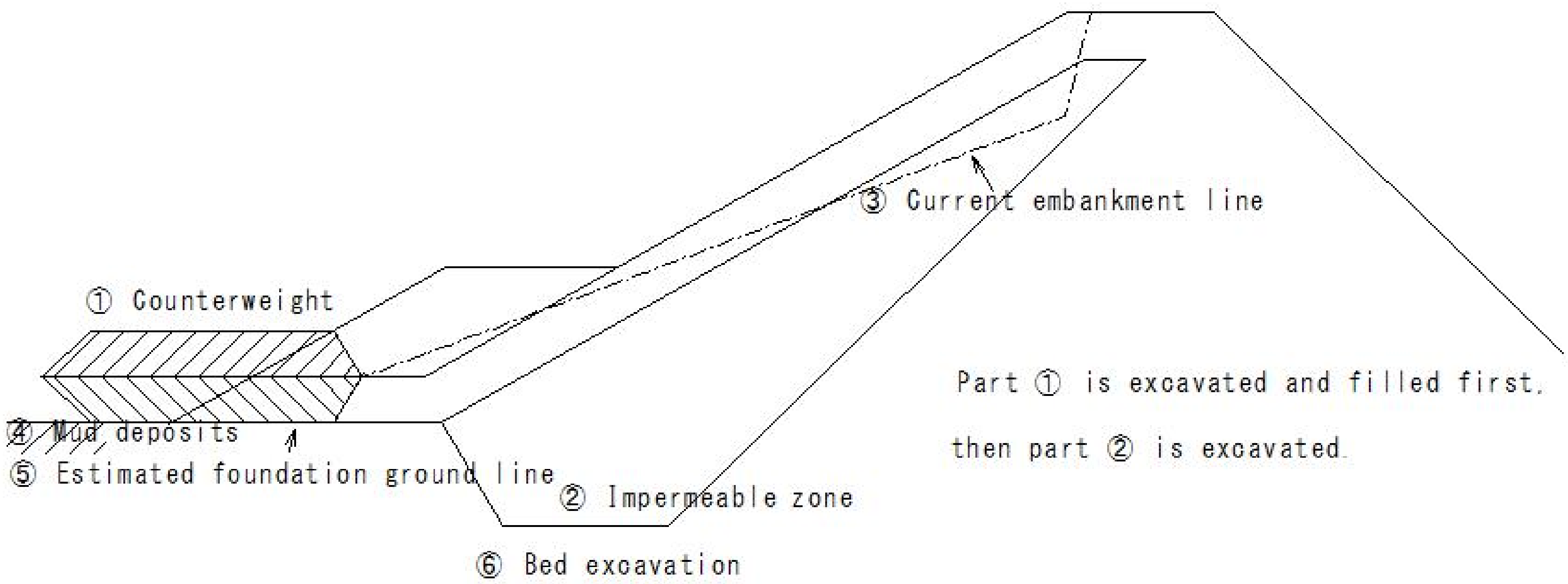


Figure 4.2.4 Example of embankment in upstream area

(I1696) Reservoir Development

(I1696) Reservoir Development

4.2 Construction

○ Excavation is slightly wider than the area of one embankment, making drainage easier and improving workability.

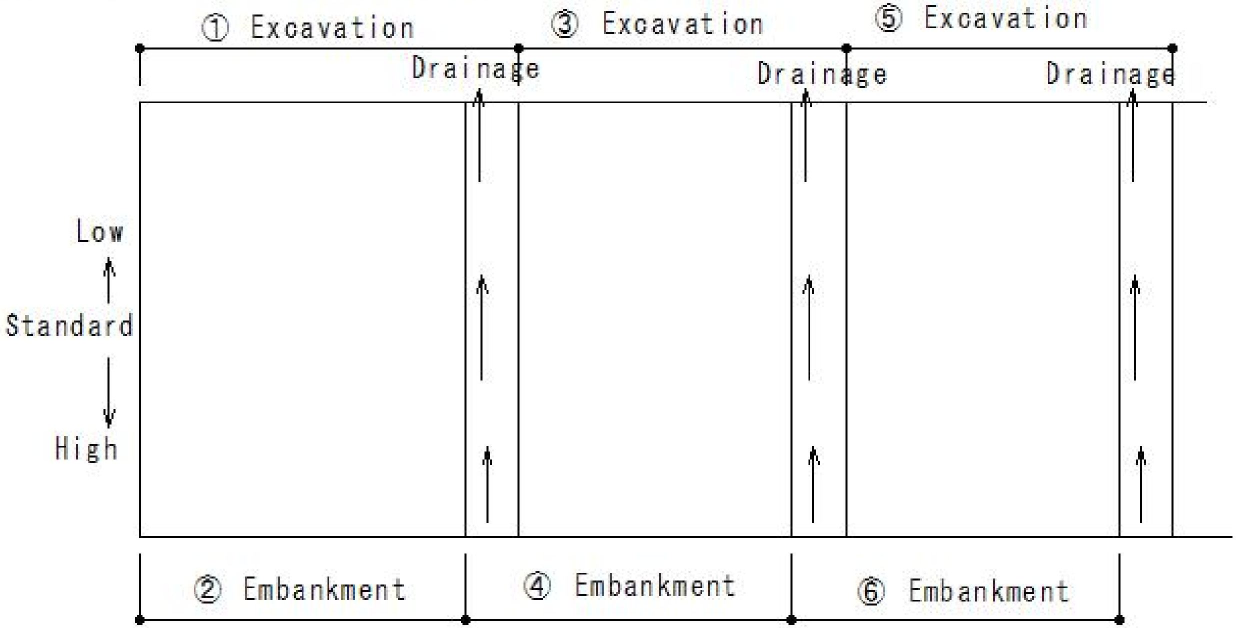


Figure-4.2.5 Improvement of workability

(I1697) Reservoir Development

(I1697) Reservoir Development

4.2 Construction

○ Shape of excavated foundation ground - Avoid significant changes

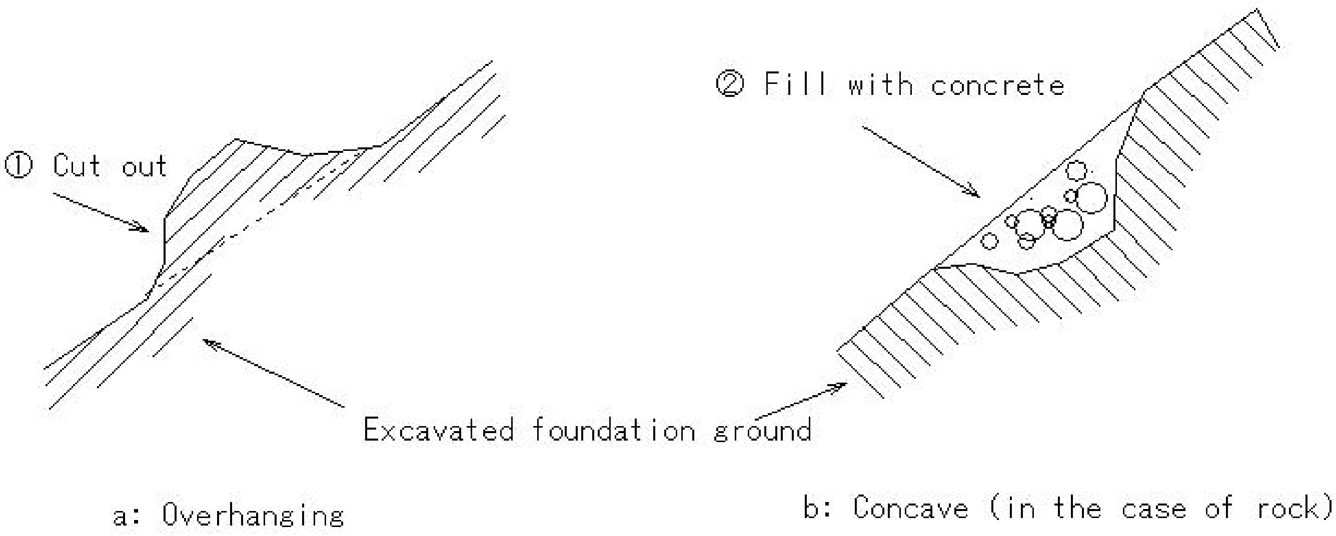


Figure 4.2.6 Shaping the foundation ground

(I1698) Reservoir Development

4.2 Construction

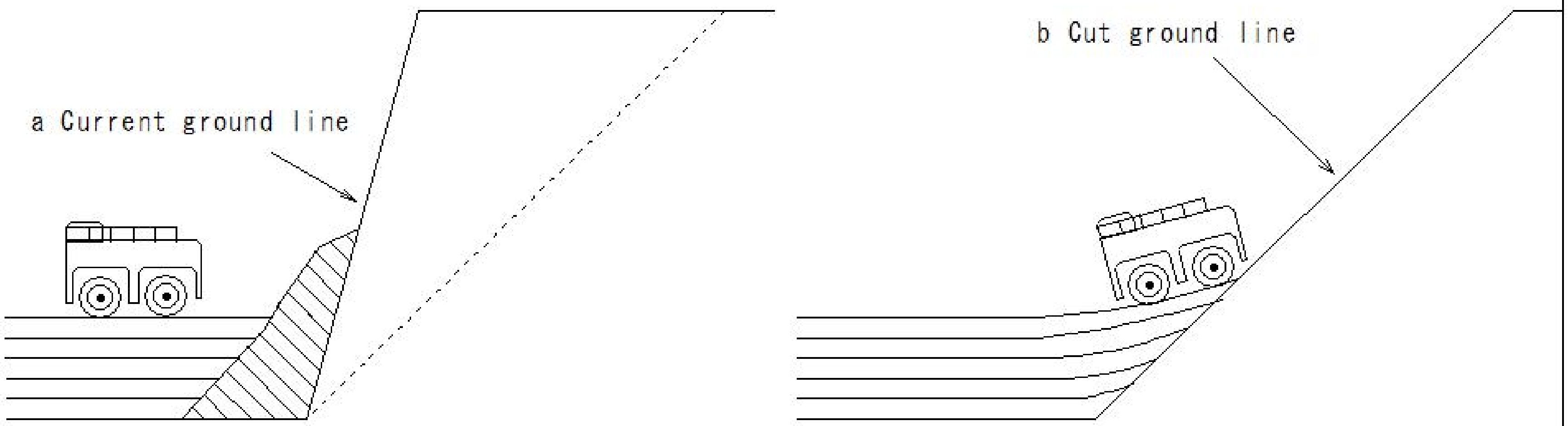


Figure-4.2.7 Cut ground line

(I1699) Reservoir Development

4.2 Construction

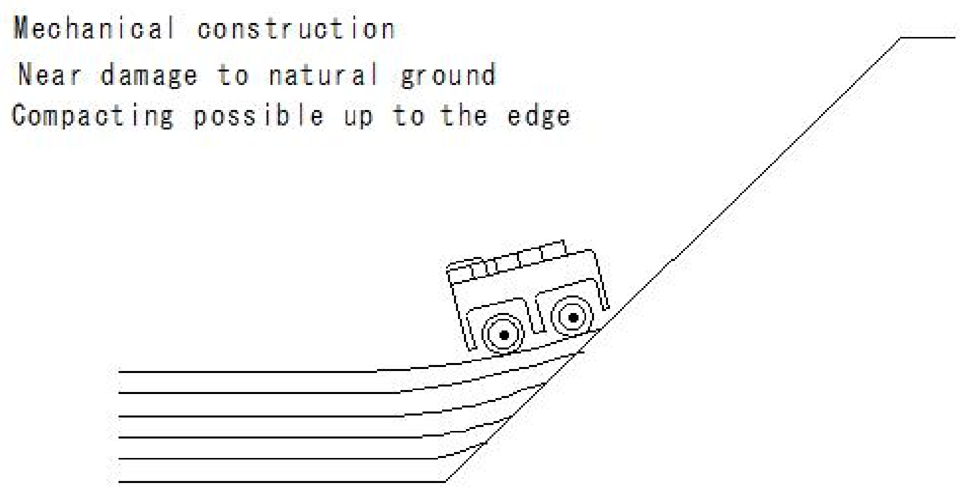


Figure 4.2.8 Construction of natural ground connections

(I1700) Reservoir Development

(I1700) Reservoir Development

4.2 Construction

Embankment slope: Add 0.5-1.0 m of embankment and scrape off to a regular cross section

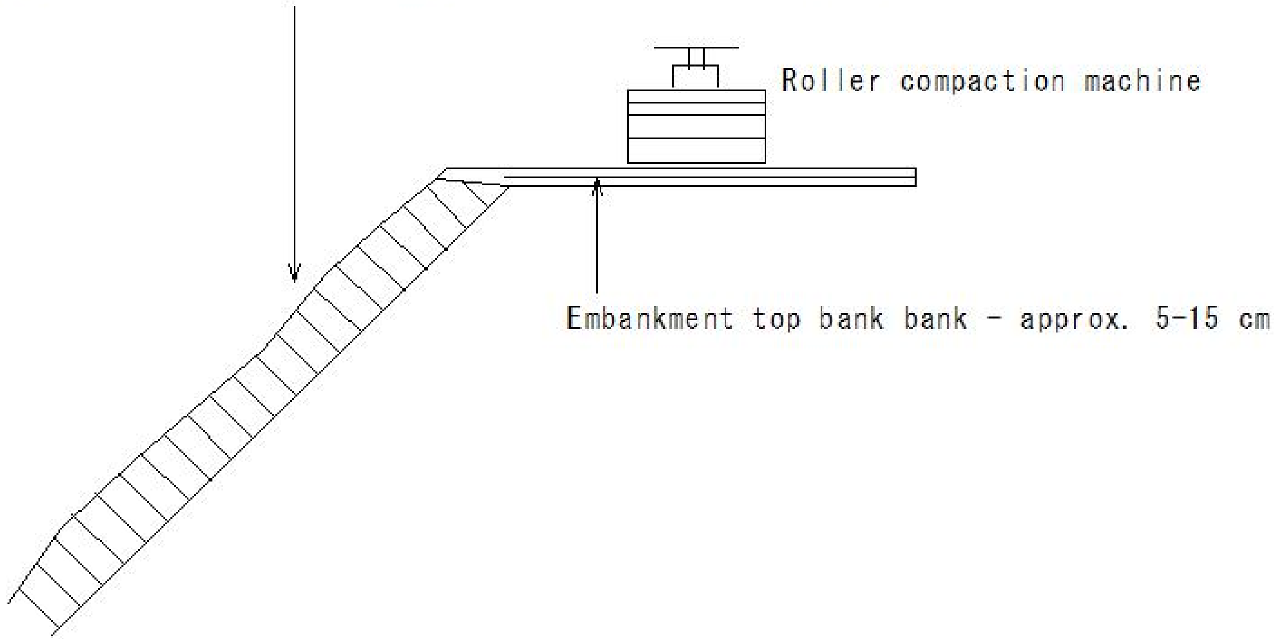


Figure 4.2.9 Embankment top bank

(I1701) Reservoir Development

(I1701) Reservoir Development

4.2 Construction

Treatment of spring water and precipitation

*Collect spring water etc. in one place and pile it up

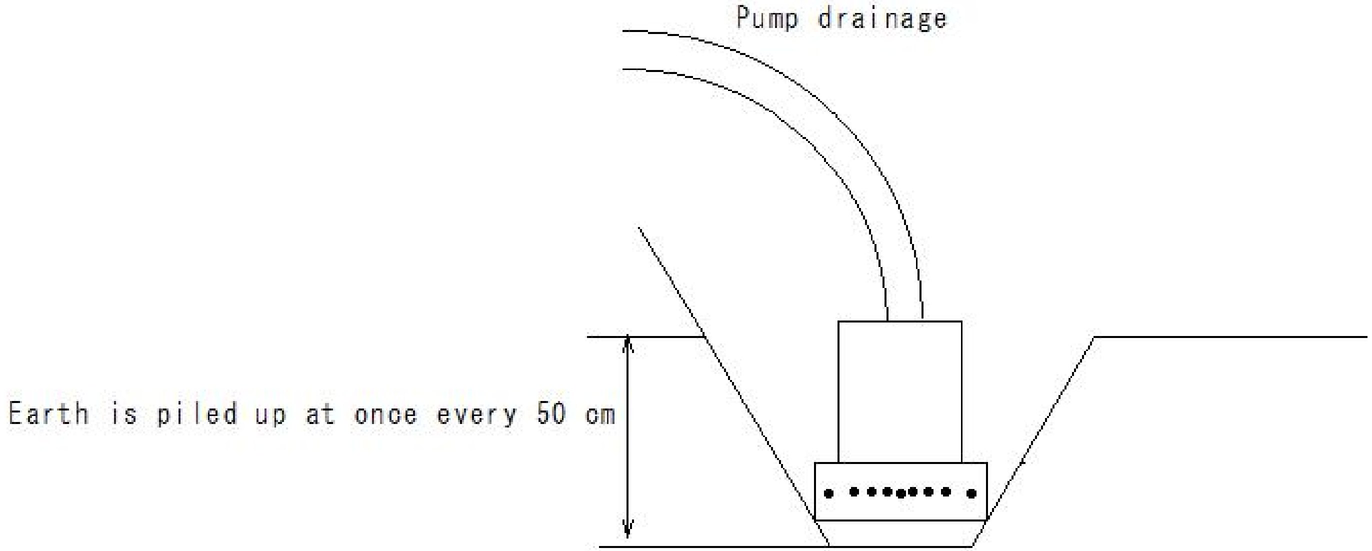


Figure 4.2.10 Treatment of spring water and precipitation

(I1702) Reservoir Development

(I1702) Reservoir Development

4.2 Construction

Treatment of spring water and precipitation

① Insert a cylinder and compact the surrounding area

② After removing the cylinder, pump out the water and quickly backfill with water-impermeable materials

Figure 4.2.11 Embankment method using water-impermeable materials when there is little spring water

(I1703) Reservoir Development

(I1703) Reservoir Development

4.2 Construction

Treatment of spring water and precipitation

① Cylinder

② Add small gravel and compact the surrounding area

③ Inject thick grout milk at low pressure

④ Remove air

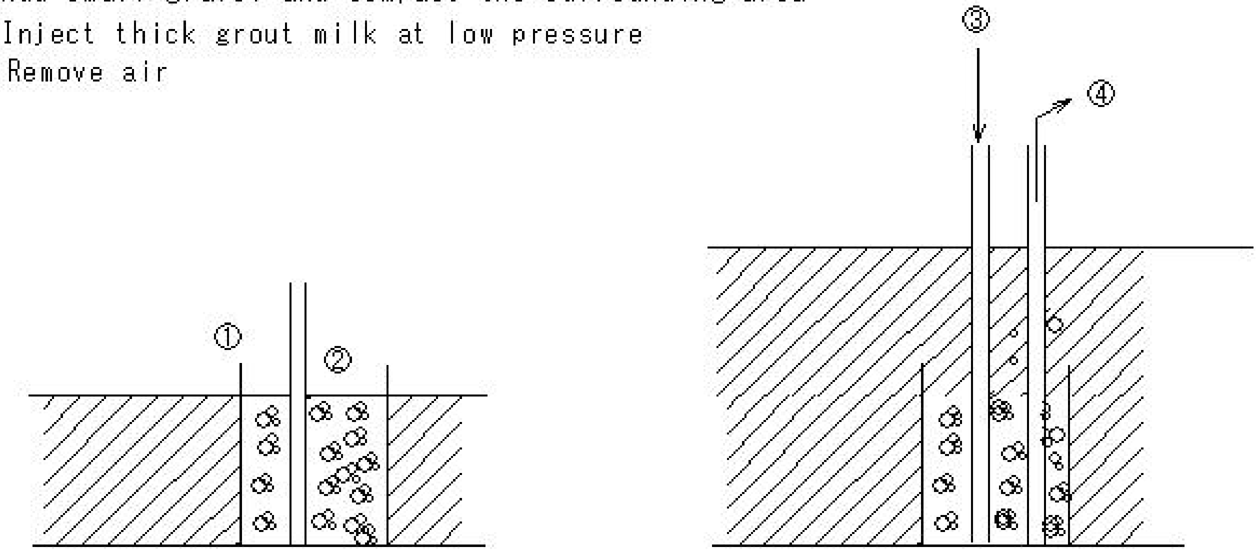


Figure 4.2.12 Embankment method using water-impermeable materials when there is a lot of spring water

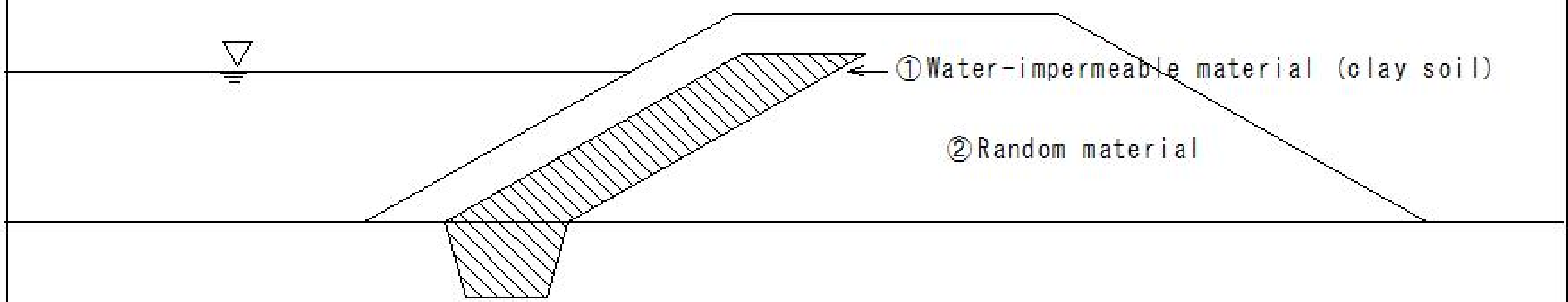
(I1704) Reservoir Development

(I1704) Reservoir Development

Table 4.3.1 Quality control items

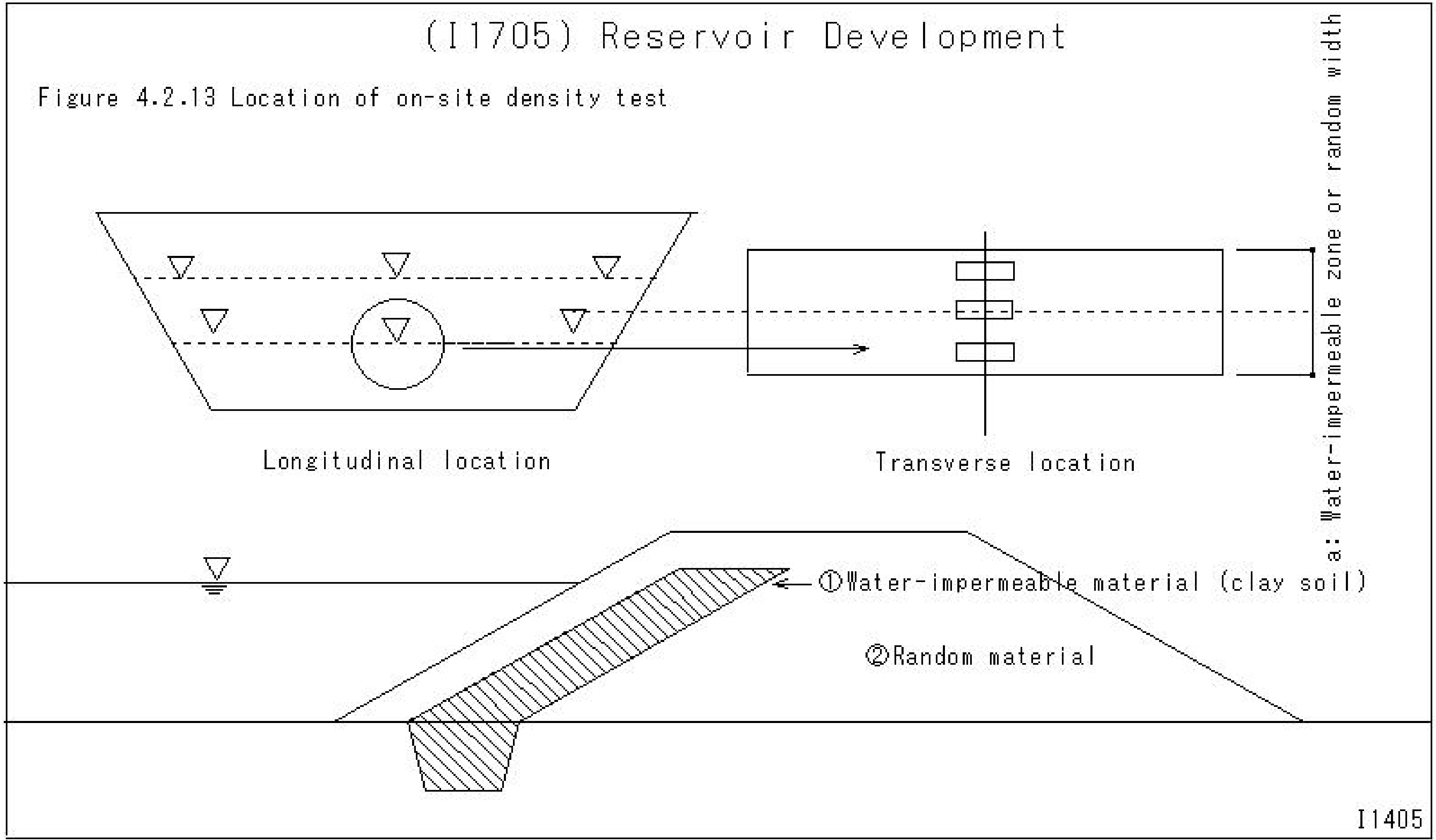
A: Water-impermeable zone
① Soil particle density test
② Grain size test
③ Moisture content test
④ Soil compaction test by tamping
⑤ On-site density measurement
⑥ On-site permeability test

B: Random
① Soil particle density test
② Grain size test
③ Moisture content test
④ Soil compaction test by tamping
⑤ On-site density measurement



I1405

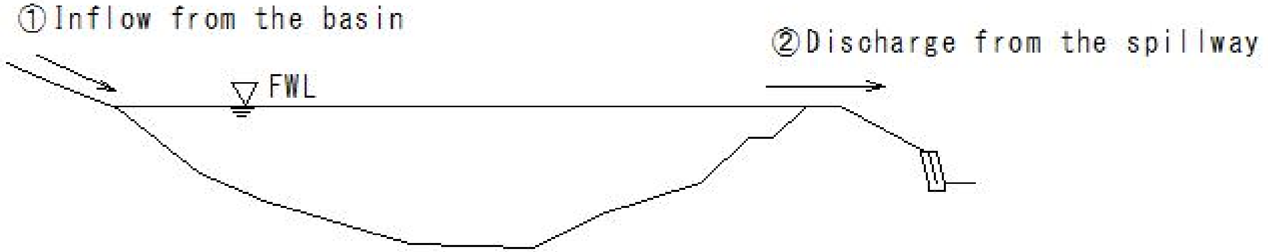
(I1705) Reservoir Development



(I1706) Reservoir Development

(I1706) Reservoir Development

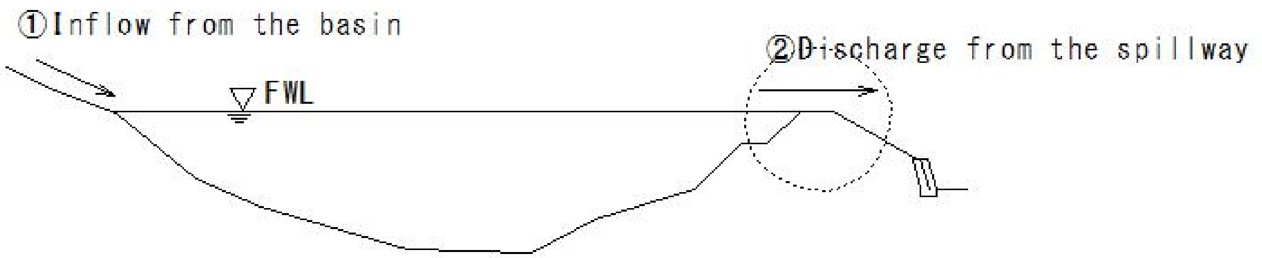
1.4 Retention effect



(I1707) Reservoir Development

(I1707) Reservoir Development

1.4 Retention effect



Spillway is overflow type

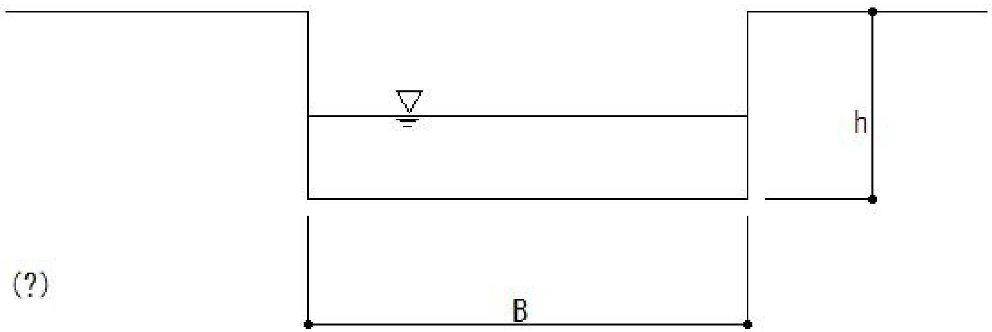
$Q=C \cdot h^{3/2}$

Q: Discharge amount (m3/s)

C: Overflow coefficient 2.1

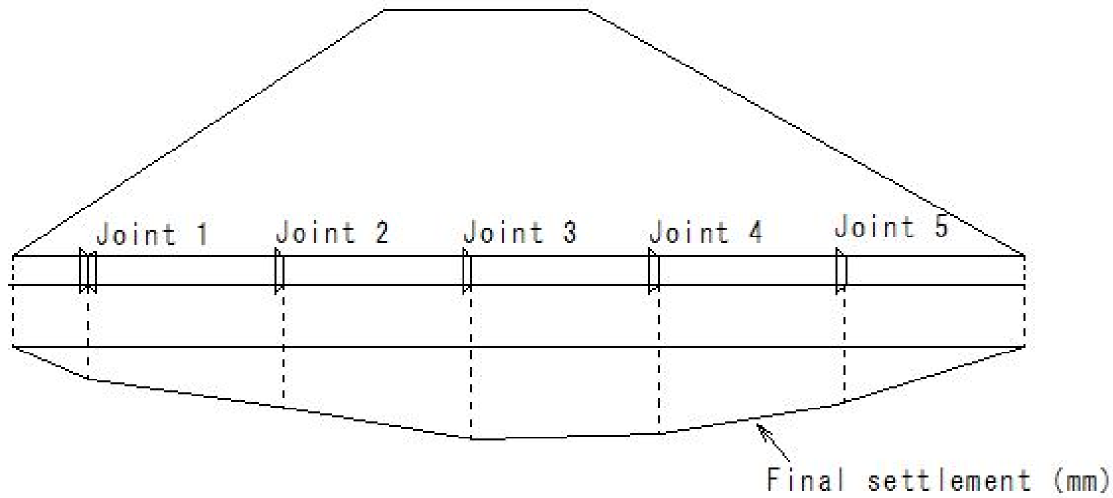
B: Effective width of weir 4.4m

h: Water depth (total overflow head) (?)



(I1708) Reservoir Development

Figure 5 Ground displacement and bottom drain pipe displacement



I1685

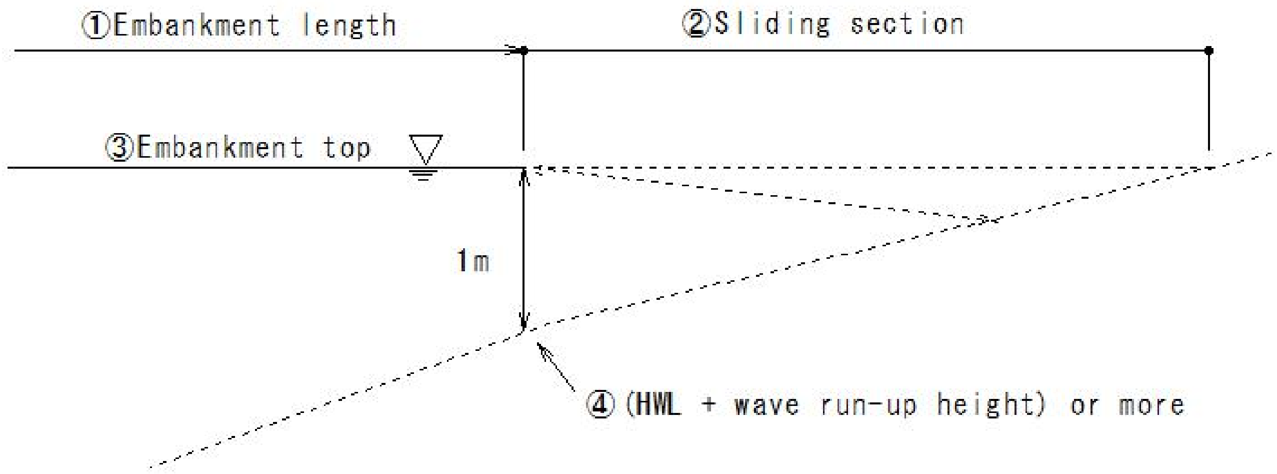
(I1709) Reservoir Development

(I1709) Reservoir Development

Reference materials

1. Relationship between embankment and ground height

Example 1: In case of the ground around the reservoir is lower than the planned embankment height



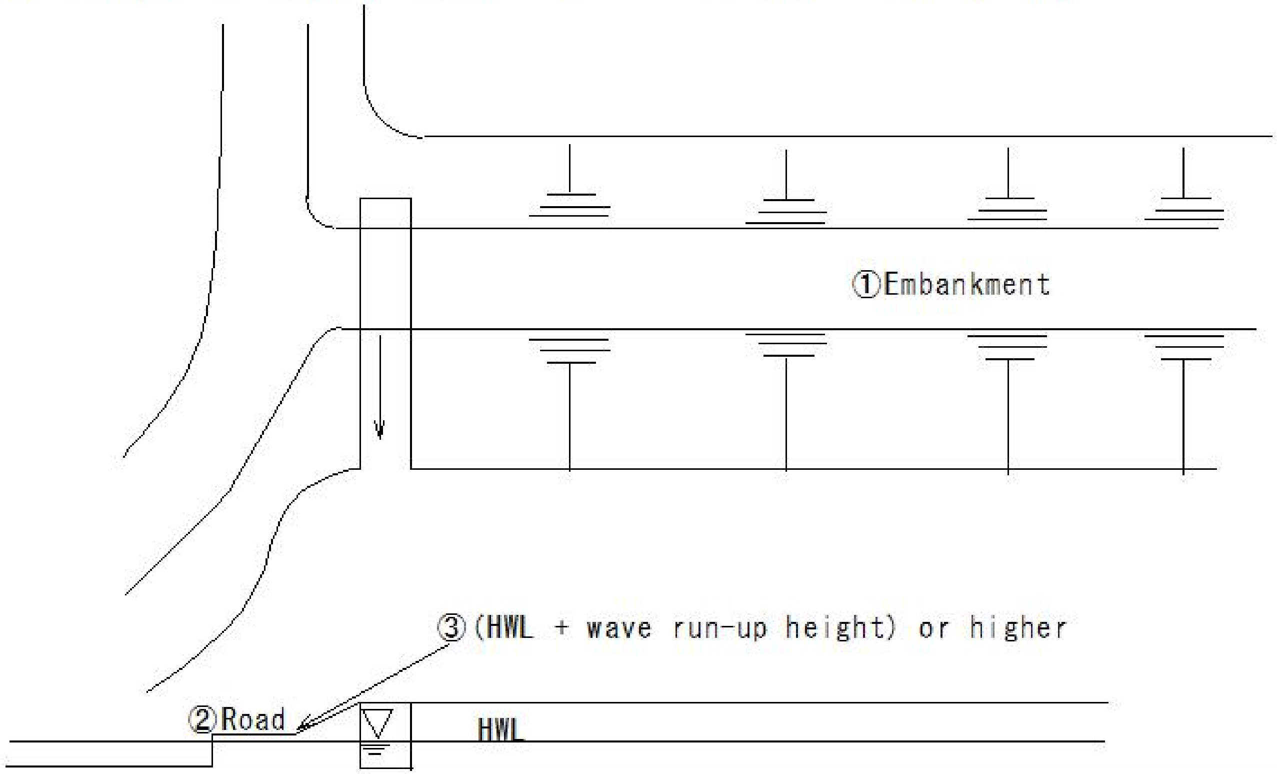
Reference 1-1: Sliding of the start and end of the embankment

(I1710) Reservoir Development

(I1710) Reservoir Development

Reference diagram 1-2: Alignment of the main embankment start and end

Example 2: In case of the ground around the flood area is lower than the embankment design height, install a parapet or secondary embankment at the border with the road



(I1711) Reservoir Development

2.1.3 Base and base layer of waterproof sheet

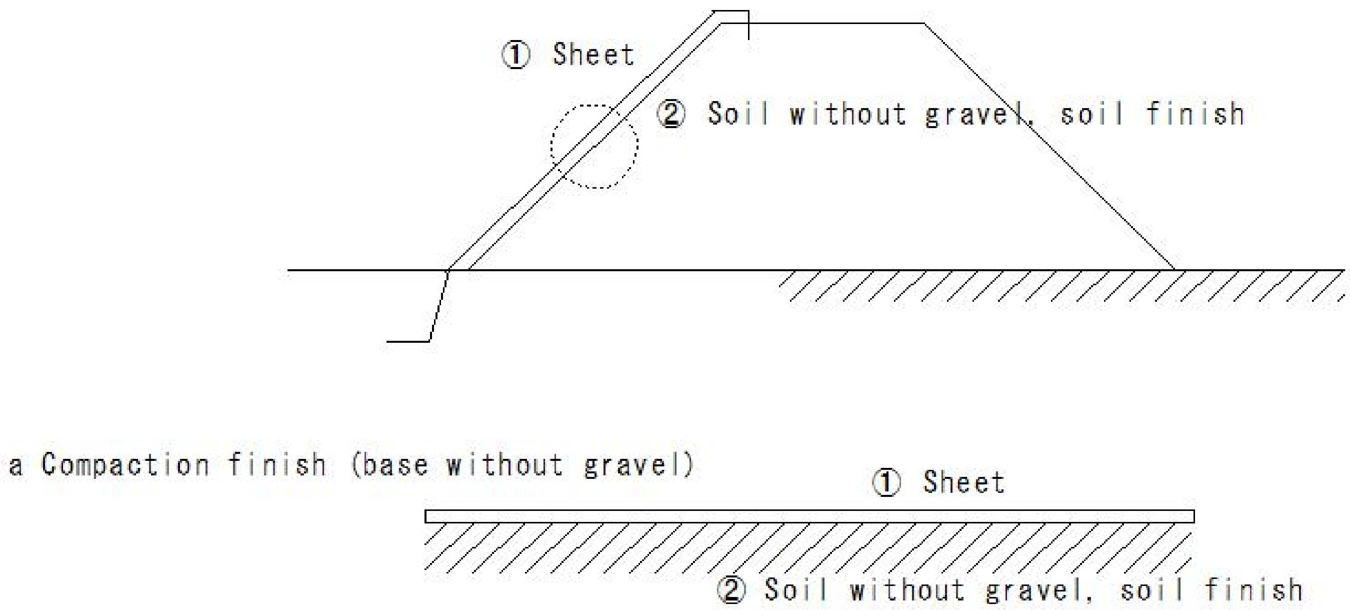
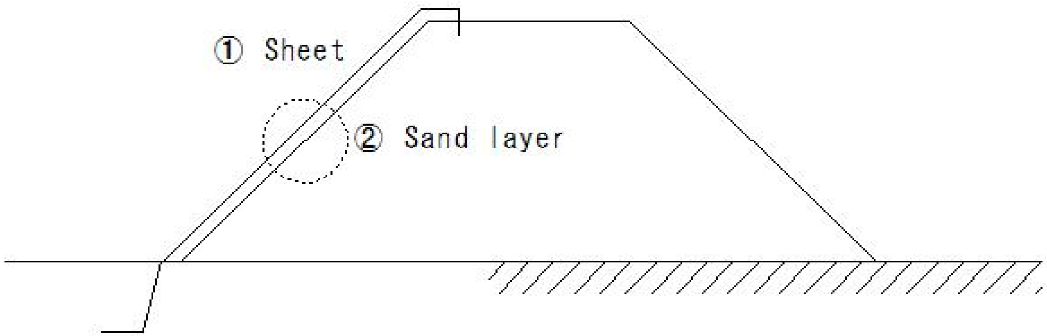


Figure 2.1.2 Base and base layer of waterproof sheet

(I1712) Reservoir Development

2.1.3 Base and base layer of waterproof sheet



b Sand layer 5-10cm thick (bottom gravel soil, bottom soft ground)

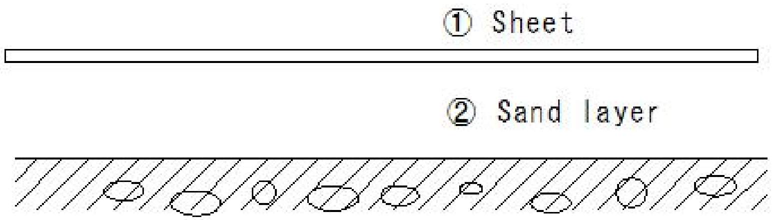
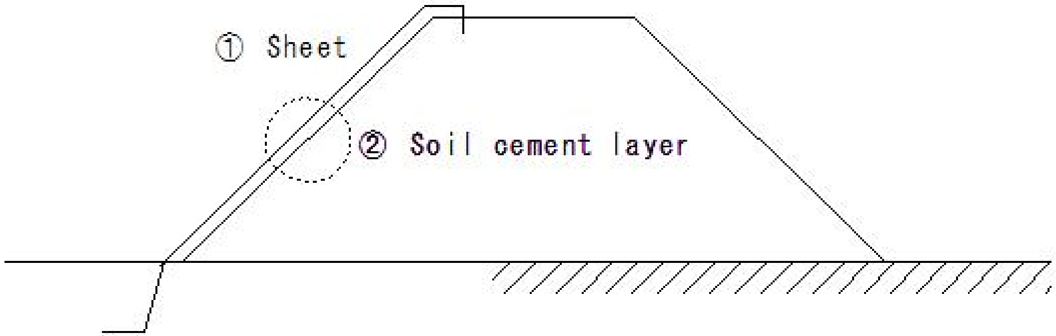


Figure 2.1.2 Base and base layer of waterproof sheet

(I1713) Reservoir Development

2.1.3 Base and base layer of waterproof sheet



c Soil cement layer 5-10cm thick (gravel soil on slope)

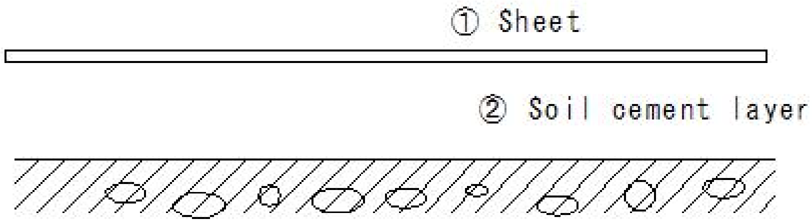


Figure 2.1.2 Base and base layer of waterproof sheet

(I1714) Reservoir Development

2.1.3 Base and base layer of waterproof sheet

d Mortar smoothing layer 5-10cm thick (soft rock gravel area)

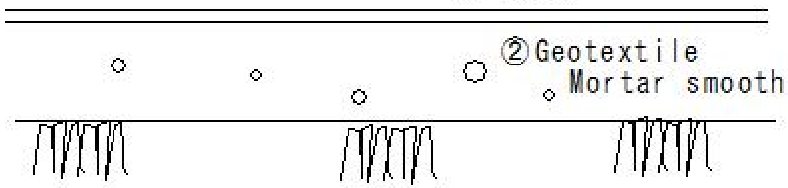
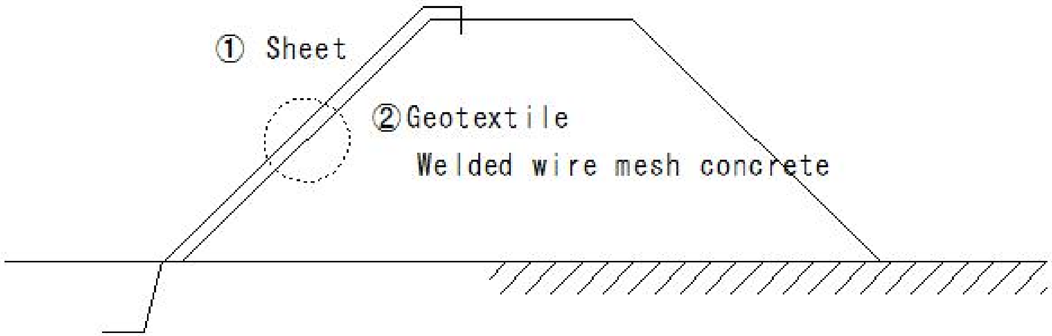


Figure 2.1.2 Base and base layer of waterproof sheet

(I1715) Reservoir Development

2.1.3 Base and base layer of waterproof sheet



e. Welded wire mesh concrete 10cm thick (masonry)

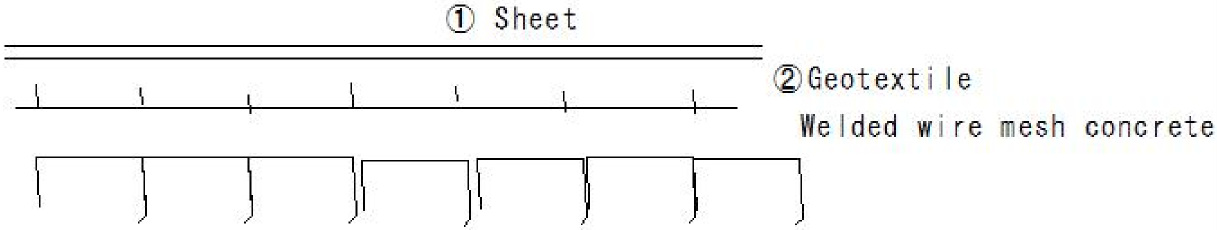
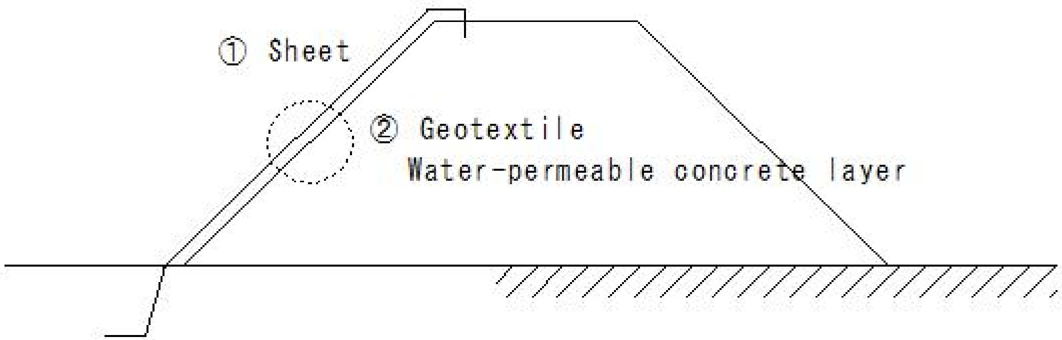


Figure 2.1.2 Base and base layer of waterproof sheet

(I1716) Reservoir Development

2.1.3 Base and base layer of waterproof sheet



f Water-permeable concrete layer 10cm thick (for frost heave prevention, seepage slope, seepage bottom)

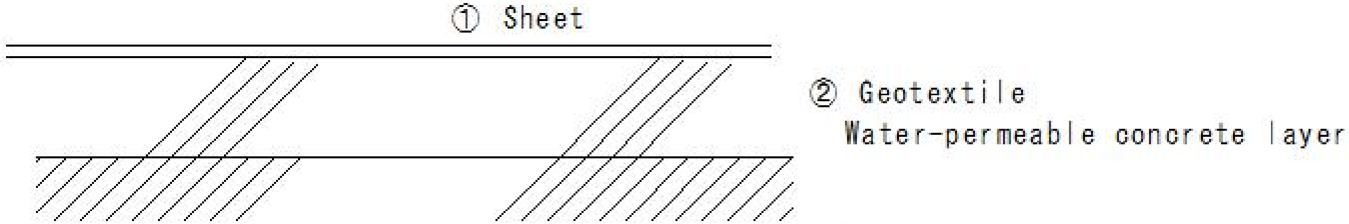


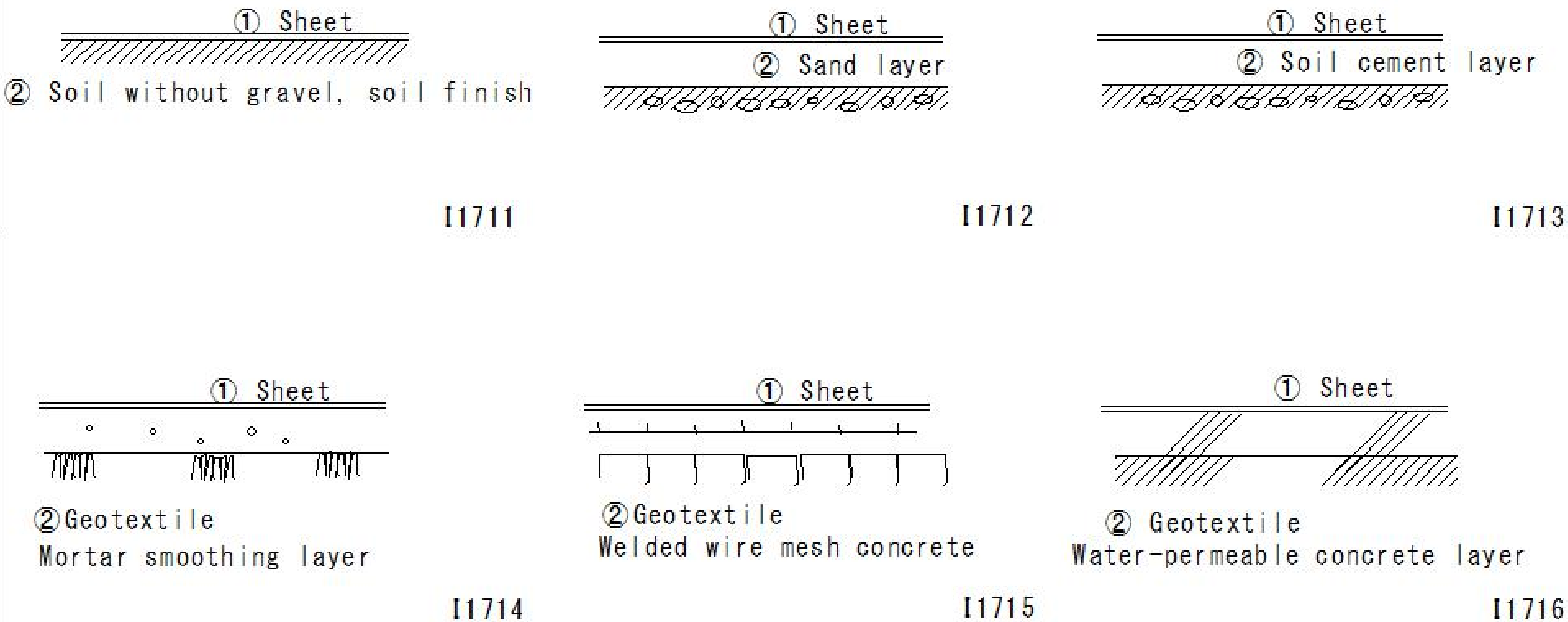
Figure 2.1.2 Base and base layer of waterproof sheet

(I1717) Reservoir Development

(I1717) Reservoir Development

2.1.3 Base and base layer of waterproof sheet

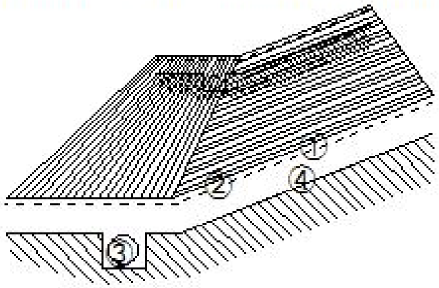
Figure 2.1.2 Base and base layer of waterproof sheet



(I1718) Reservoir Development

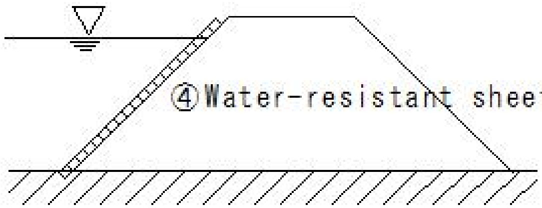
(I1718) Reservoir Development

2.1.3 Base and base layer of waterproof sheet

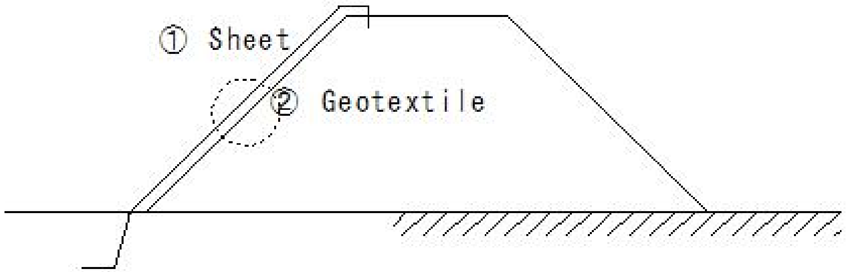


①Water-resistant sheet
②Treatment using geotextiles, etc.
③Drain pipe
④Installation of base treatment layer and drainage layer
Crusher run, stabilized soil I106

○Surface water-resistant type



I1644



I1711

(I1719) Reservoir Development

2.1.4 Depth of penetration of waterproof sheet

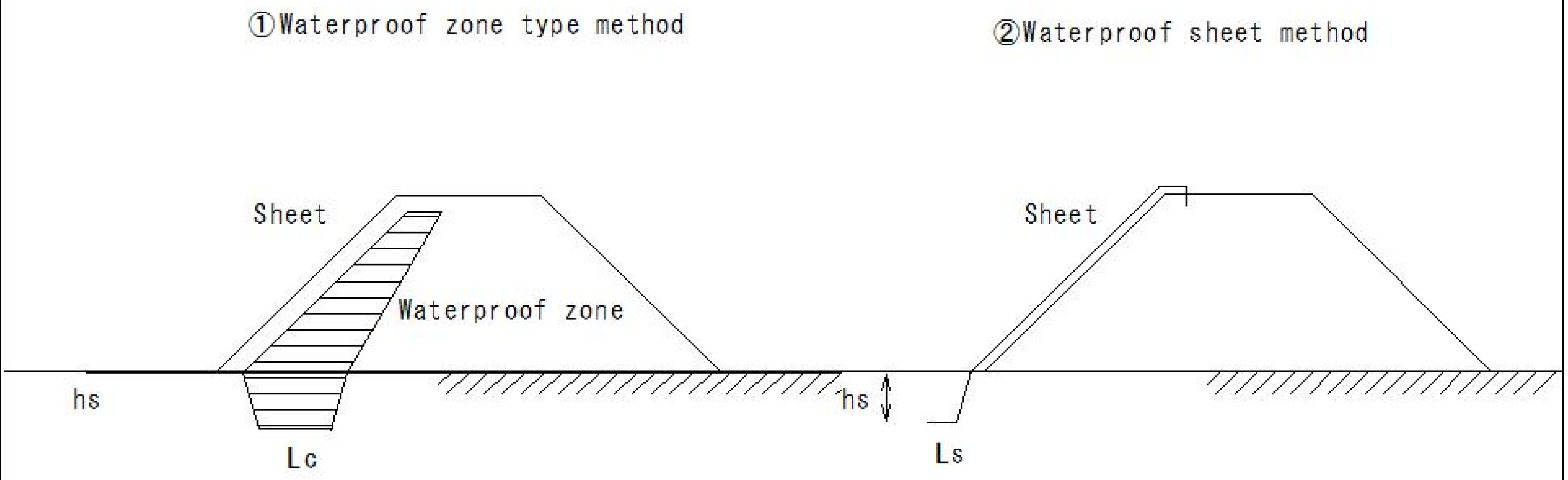


Figure 2.1.3 Depth of waterproof sheet penetration

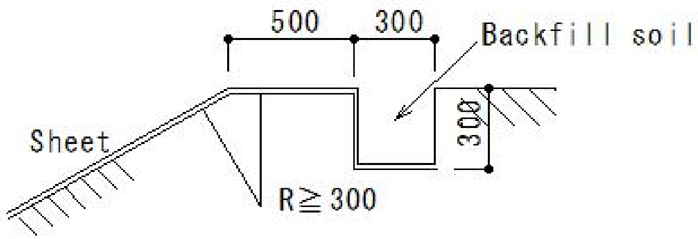
(I1720) Reservoir Development

(I1720) Reservoir Development

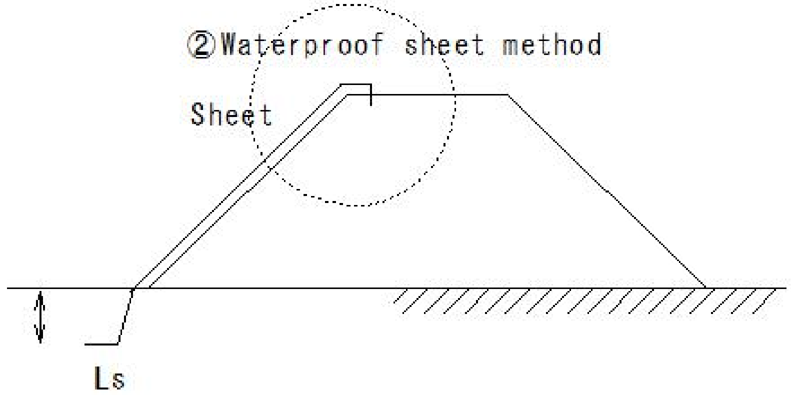
2.1.6 End treatment of waterproof sheet

Fixing at the top

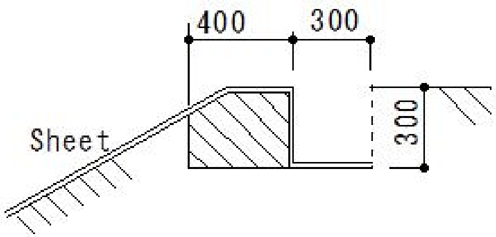
① Example of soil wing finishing

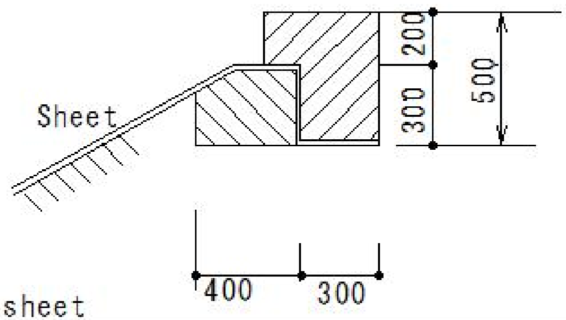


②Waterproof sheet method



② Slope shoulder concrete and embedding fixation





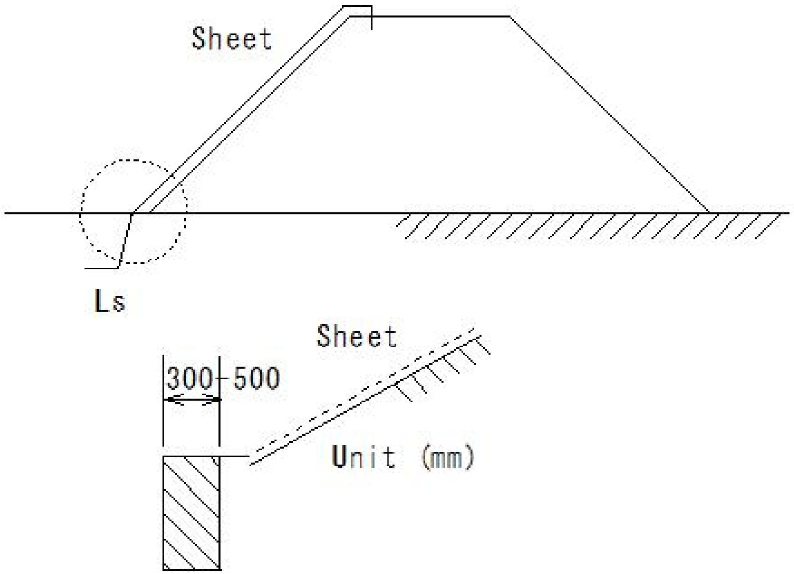
Reference diagram 2.1.5 Fixing at the top of waterproof sheet

(I1721) Reservoir Development

2.1.6 End treatment of waterproof sheet

Treatment of waterproof sheet at the tip and ground attachment part (terminal treatment)

②Waterproof sheet method

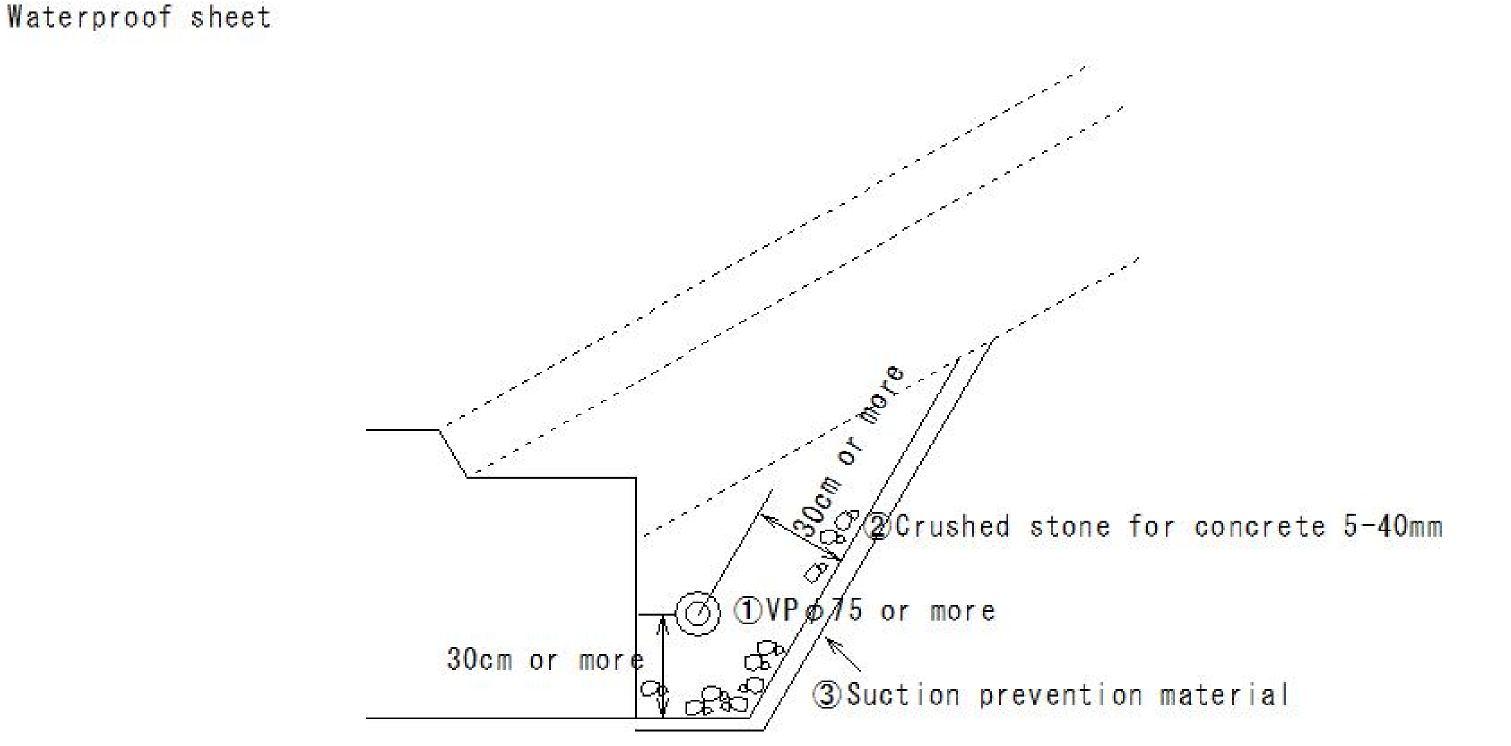


Reference diagram 2.1.6 Waterproof sheet tip fixed concrete

(I1722) Reservoir Development

(I1722) Reservoir Development

2.1.7 Countermeasures against back pressure of waterproof sheets

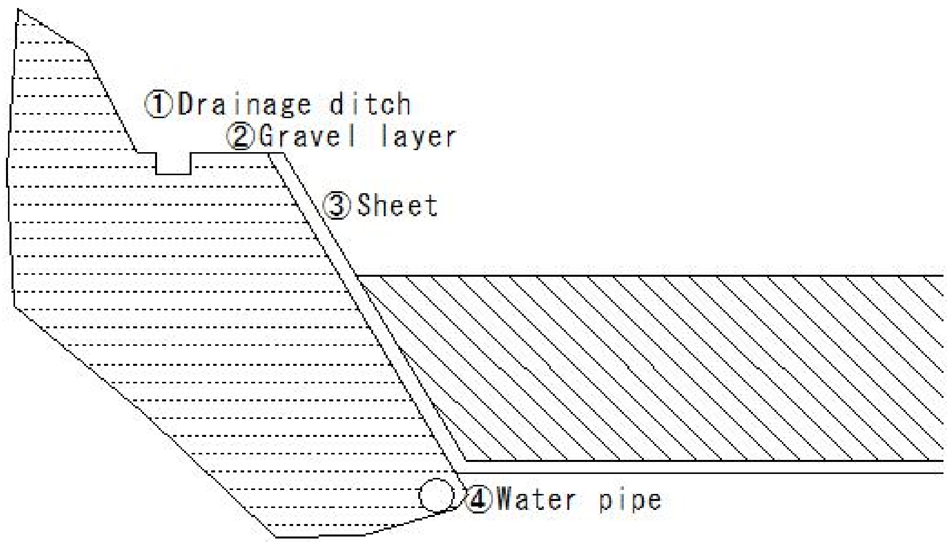


Reference diagram 2.1.7 Drains at the bottom of the embankment slope and at the berm

(I1723) Reservoir Development

2.2.3 Foundation treatment

Waterproof sheet

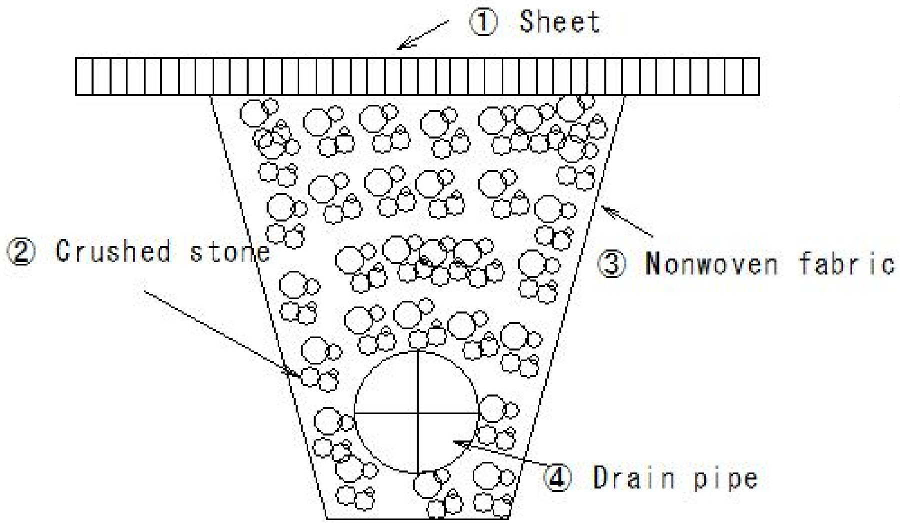


Reference diagram 2.2.2 Example of drain placement

(I1724) Reservoir Development

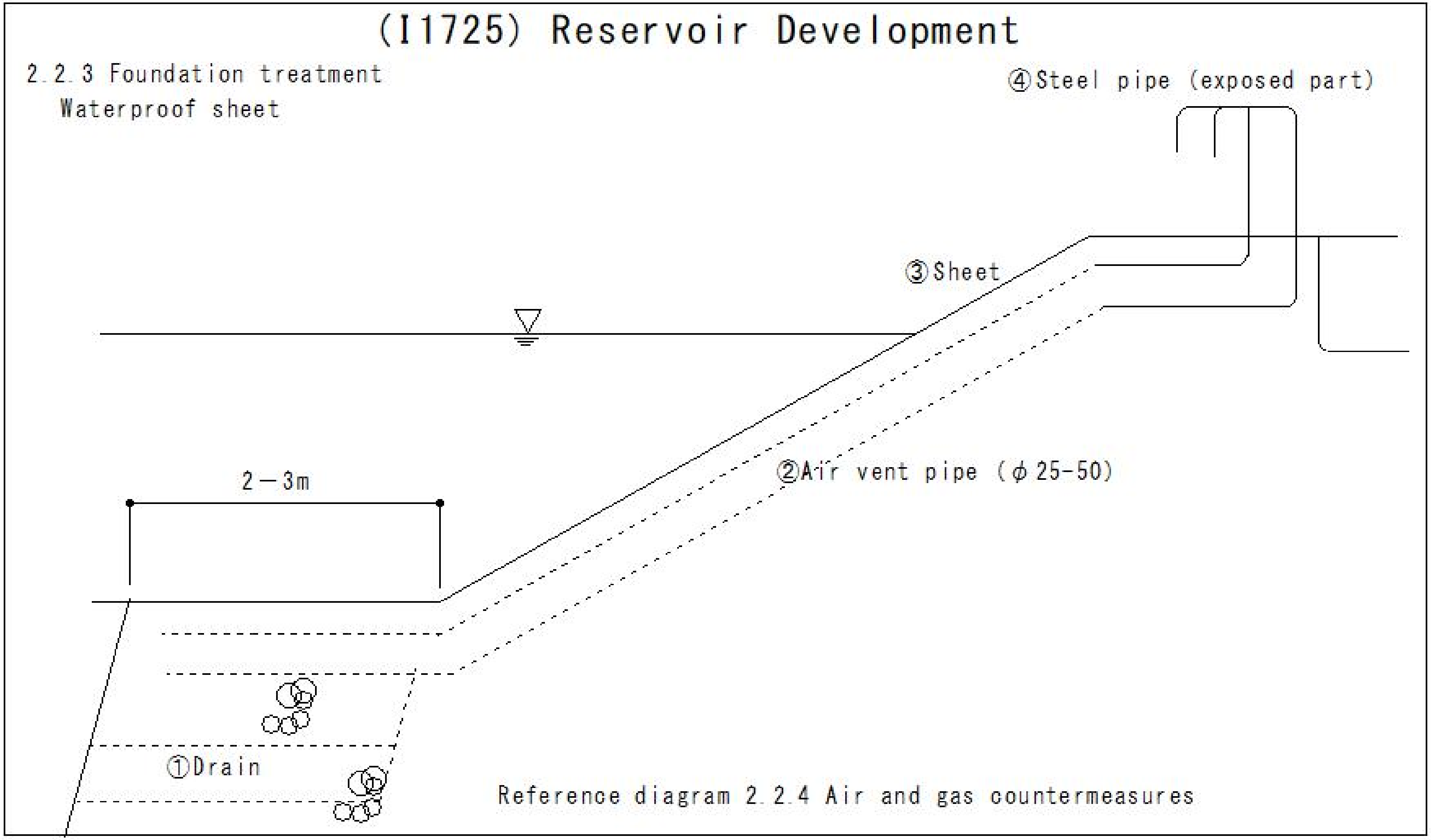
2.2.3 Foundation treatment

Waterproof sheet

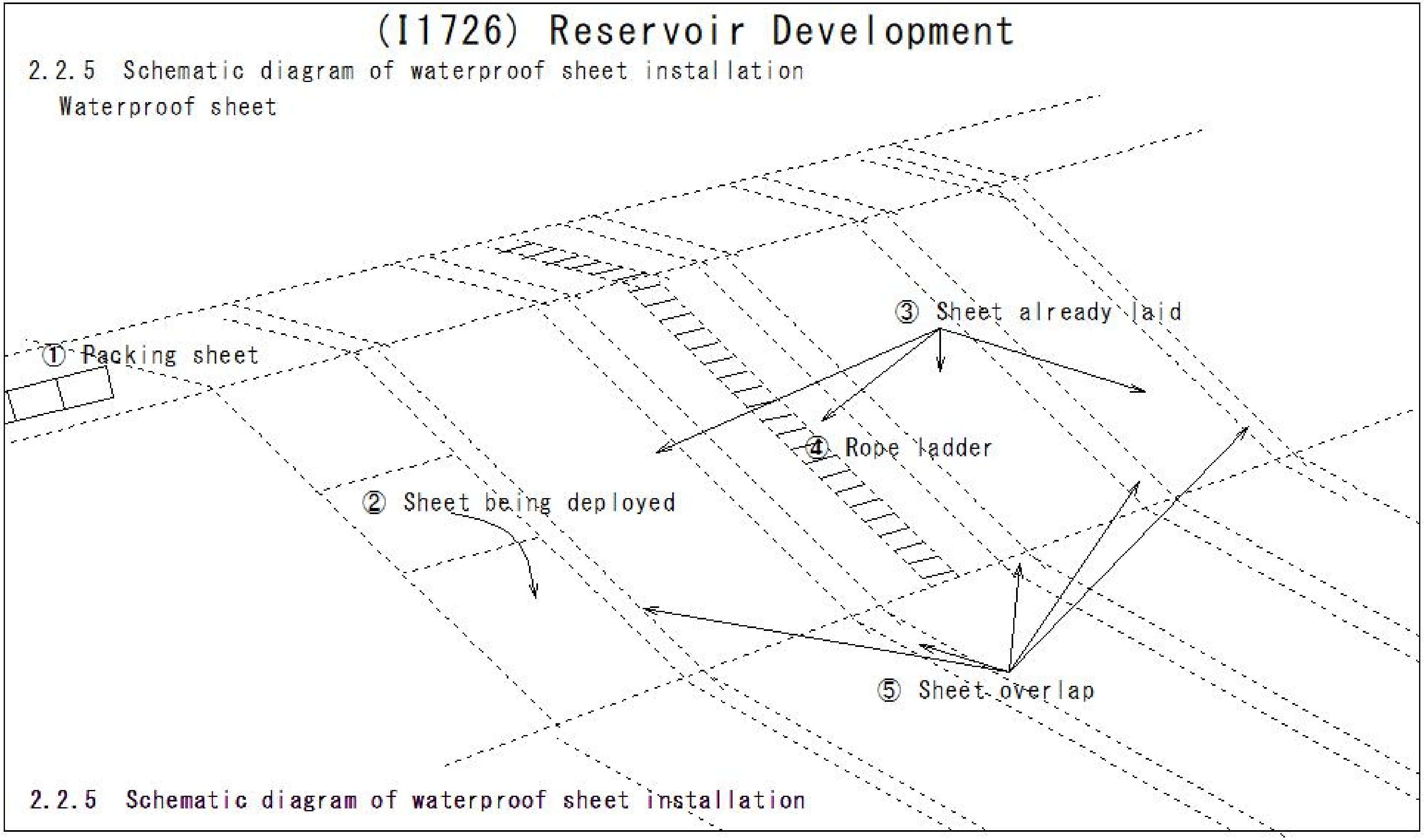


Reference diagram 2.2.3 Cross section of drain

(I1725) Reservoir Development



(I1726) Reservoir Development



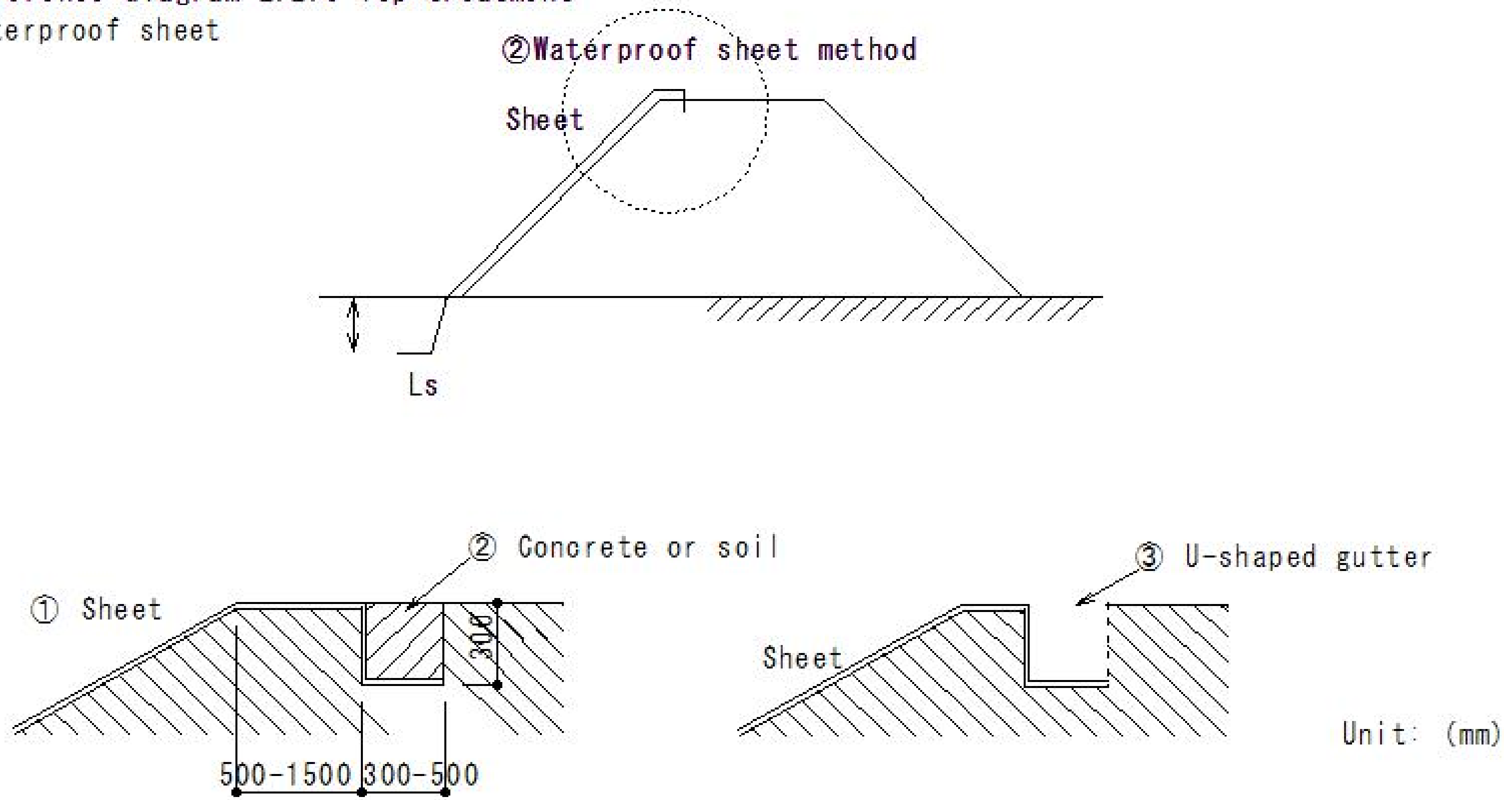
(I1727) Reservoir Development

(I1727) Reservoir Development

2.2.6 End treatment (top fixing)

Reference diagram-2.2.6 Top treatment

Waterproof sheet



Reference diagram-2.2.6 Top treatment

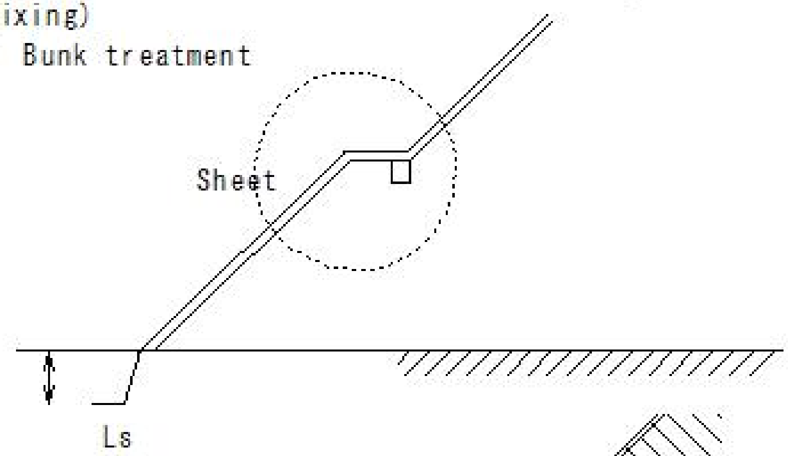
(I1728) Reservoir Development

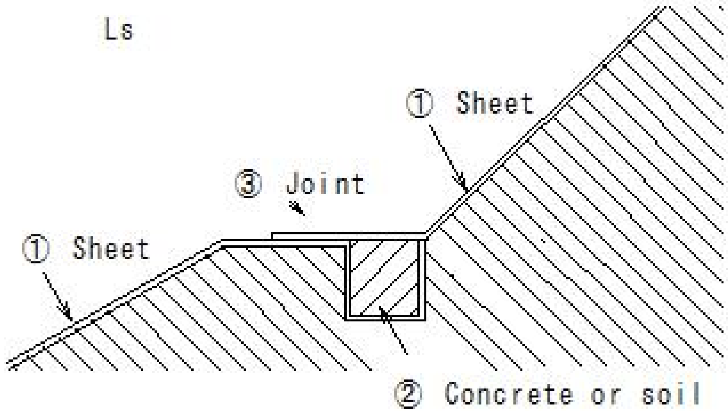
(I1728) Reservoir Development

2.2.6 End treatment (top fixing)

Reference diagram-2.2.7 Bunk treatment

Waterproof sheet





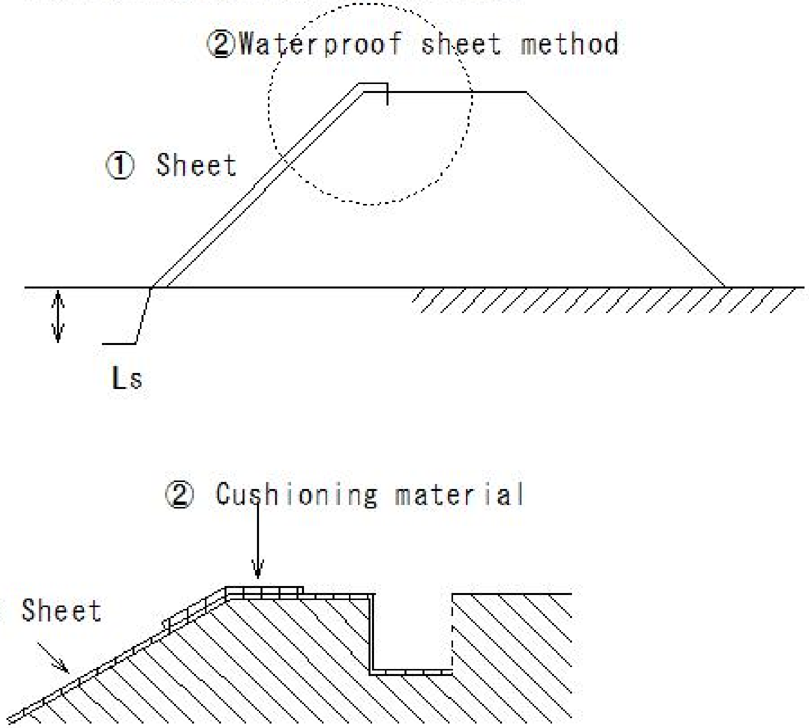
Reference diagram-2.2.7 Bunk treatment

(I1729) Reservoir Development

(I1729) Reservoir Development

2.2.6 End treatment (top fixing)

Reference diagram-2.2.8 When using cushioning material



Reference diagram-2.2.8 When using cushioning material

(I1730) Reservoir Development

2.2.7 On-site joining of sheets

Points to note when on-site joint construction of sheets

① Avoid construction at low temperatures (below about 5° C) and during rain

② Dry the bonding surface and clean it by removing mud, dust, oil, etc.

③ The adhesive is dry when it no longer sticks to your fingers

④ After the sheets are laid together, roll it down with a hand roller

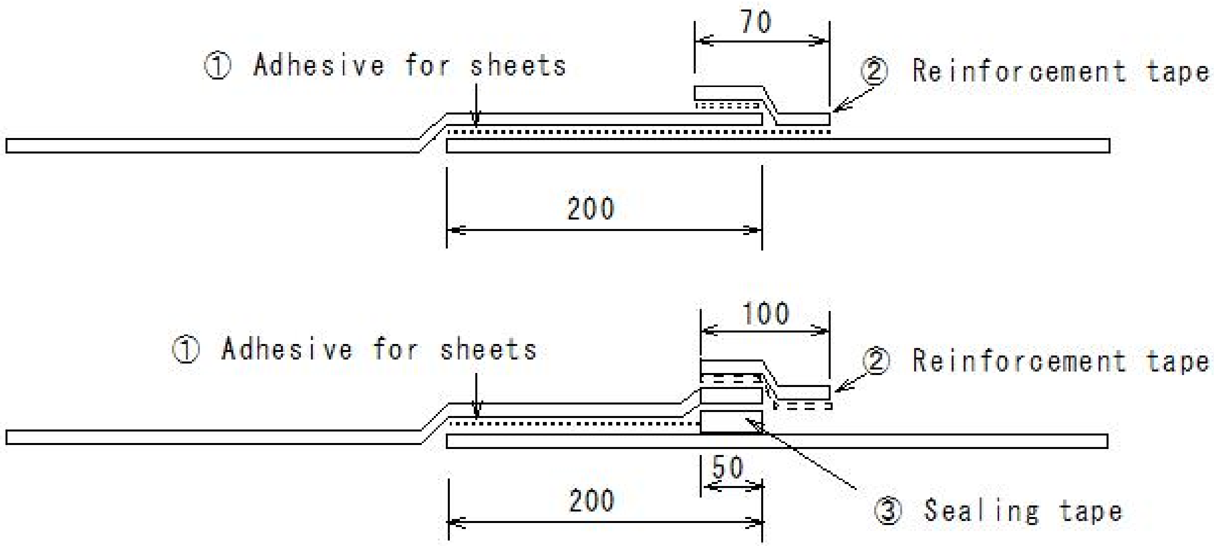


Figure 2.2.9 On-site joint construction (synthetic rubber sheets)

(I1731) Reservoir Development

2.2.7 On-site joining of sheets

○ For synthetic resin sheets

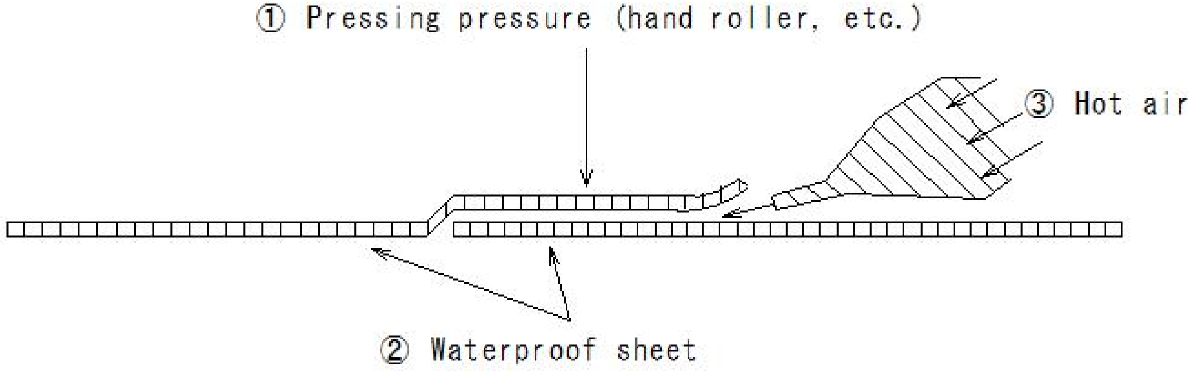


Figure 2.2.10 For portable hot air welding machine (synthetic resin sheets)

(I1732) Reservoir Development

2.2.8 Joining the sheet to the concrete structure

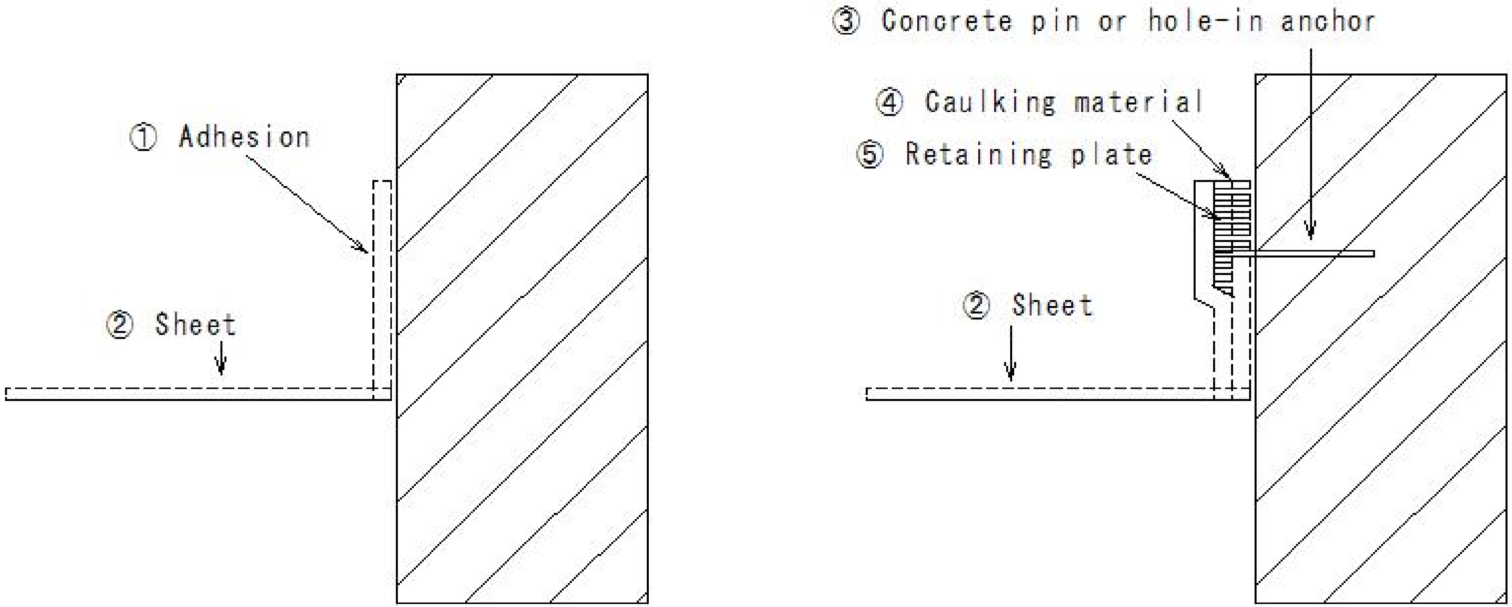


Fig. 2.2.11 How to attach the sheet to an existing concrete structure

(I1733) Reservoir Development

2.2.12 Joining sheets to concrete structures

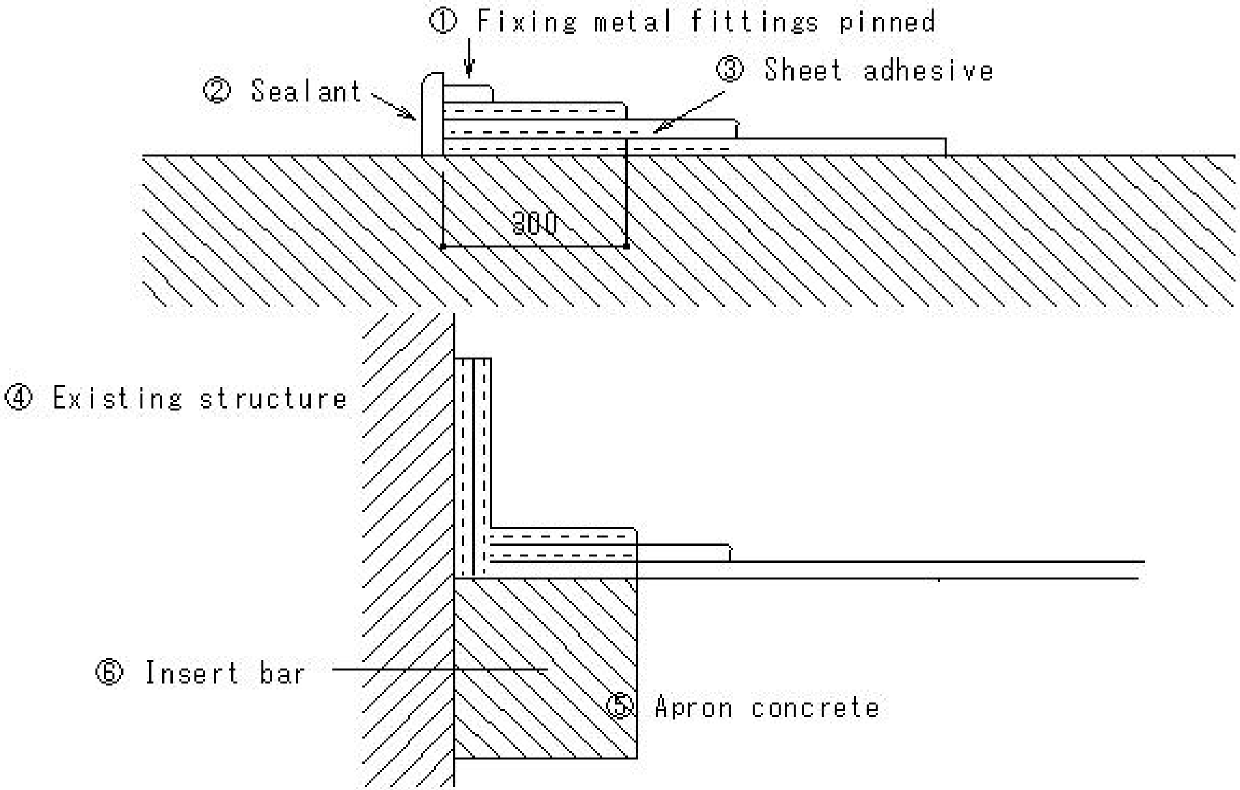


Figure 2.2.12 Application for adhesive bonding to concrete structures (independent structures) (synthetic rubber sheet)

(I1734) Reservoir Development

(I1734) Reservoir Development

2.2.12 Joining the sheet to a concrete structure

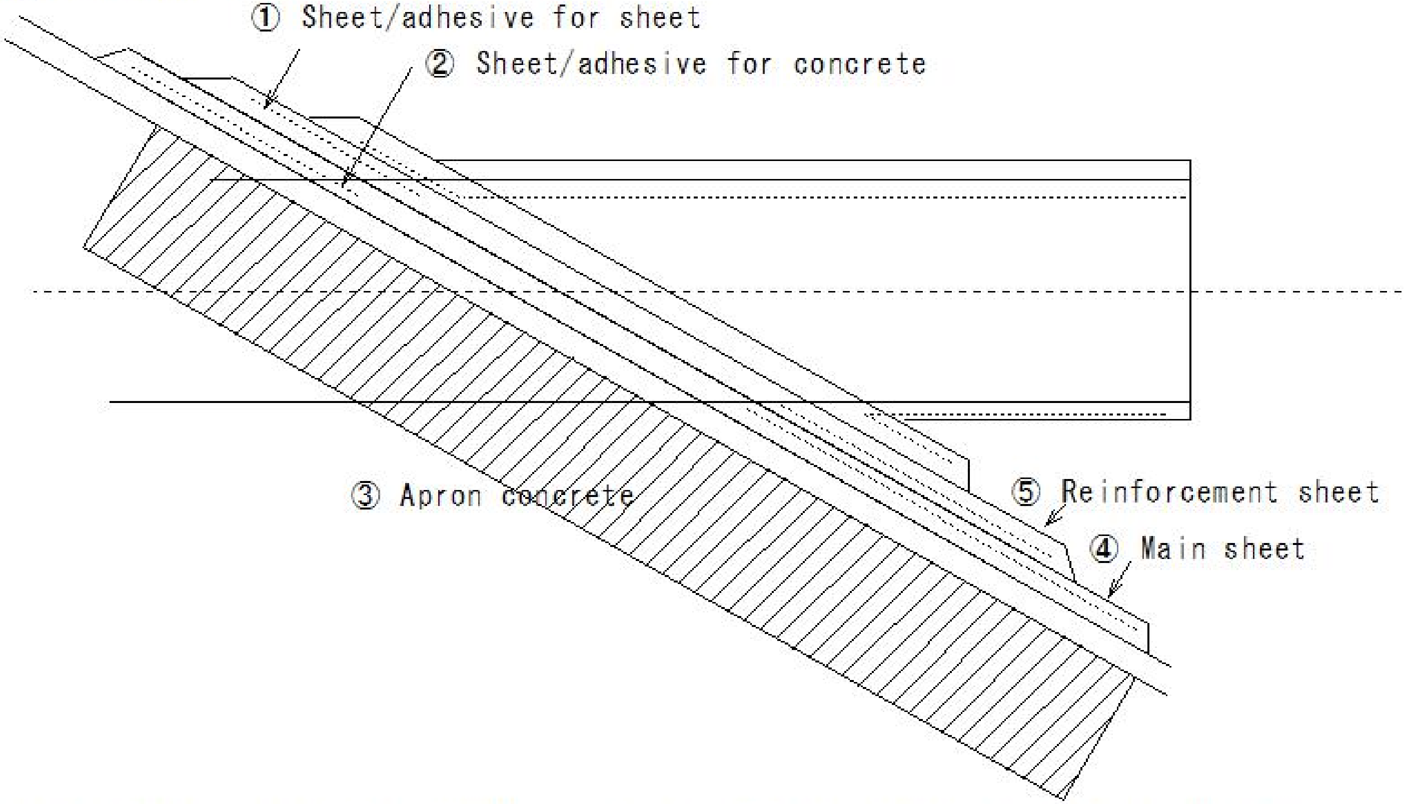


Figure 2.2.13 Application for adhesive joining to a concrete structure (around pipes)
(synthetic rubber sheet)

(I1735) Reservoir Development

3. Solidification treatment of sedimented mud in a pond

Solidification material selection and mix design

Table 3..1.1 Lime/cement-based solidification materials

○ Lime-based

① Lime-based, slaked lime

② Products made with lime as the main material, and gypsum, fly ash, slag powder, iron oxide, etc. as auxiliary materials

○ Cement-based

① Ordinary Portland cement

② Products made with cement as the main material, and gypsum, various sodas, reducing agents, etc. as auxiliary materials, or a combination of these

Table 3..1.2 Target soil classification and overview of solidification material selection

Soil classification / Solidification materials	Sandy	Silt	Clay	Organic wet soil
○ Lime-based				
○ Cement-based				

(I1736) Reservoir Development

(I1736) Reservoir Development

3.Solidification treatment of accumulated mud in a pond

○Construction of mud solidification treatment

a Construction in a reservoir

(a) In-situ treatment method (using cement slurry)

After solidification treatment in water, the reservoir is drained

It is necessary to ensure dump truck travelability when excavating and transporting the treated soil

①Solidification treatment

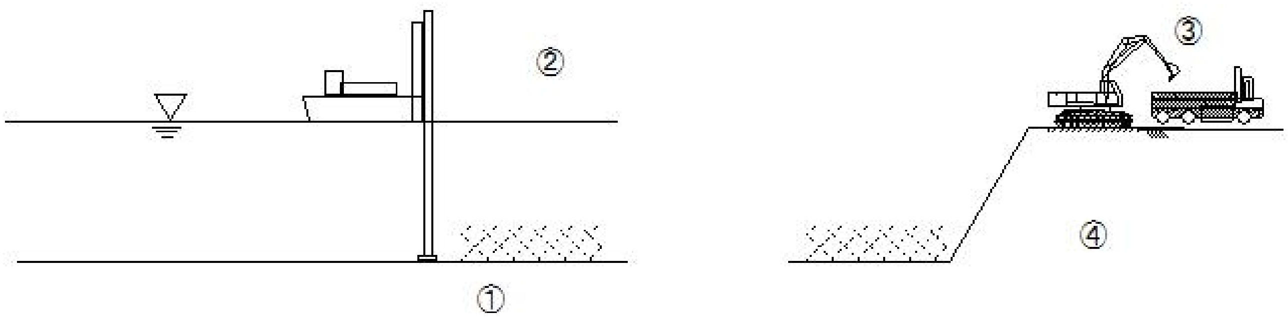
②Expose the treated soil surface by draining the water

③Prevent scattering during transportation by dump truck

qc = approx. 50kN/m2

④Target strength is to ensure dump truck travelability

qc = 1200kN/m2 or more



(I1737) Reservoir Development

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3. Solidification treatment of accumulated mud in a pond

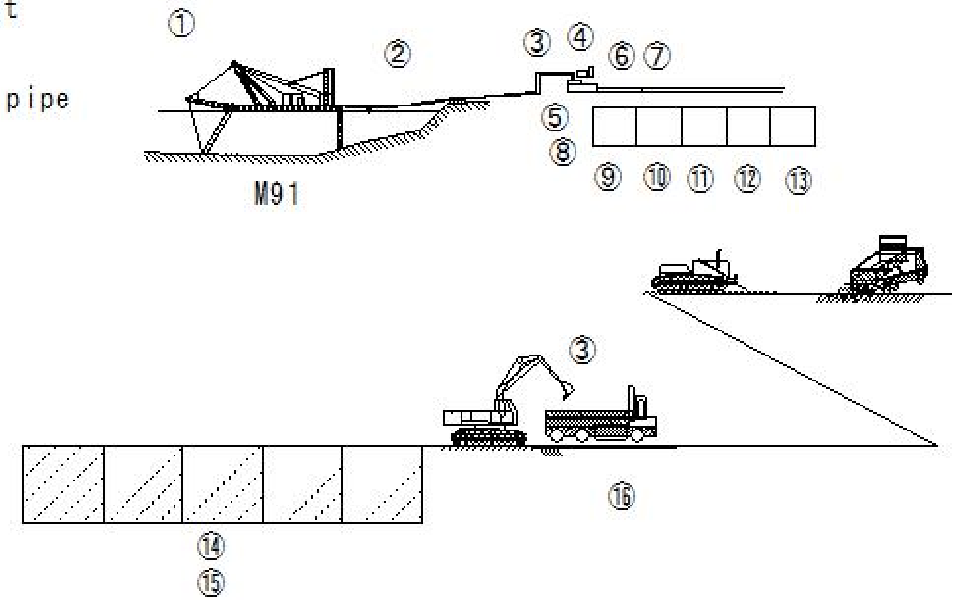
○Construction of mud solidification treatment

(b) Soil removal and processing method (using cement powder)

No need to drain water from the reservoir

Requires land for plant and curing pit

① Sludge dredger
② Air injection into sand discharge pipe
③ Mud injection
④ Material supply device
⑤ Plant
⑥ Silo
⑦ Pressure pump
⑧ Curing pit
⑨ Injection
⑩ Curing 1 day
⑪ Curing 2 days
⑫ Curing 3 days
⑬ Soil transportation
⑭ Curing about 3 days
⑮ Transport with qc = 50kN/m2 or more
⑯ Treated soil spread by disposal site (wetland bulldozer qc = 300kN/m2 or more)



(I1738) Reservoir Development

(I1738) Reservoir Development

3. Solidification treatment of accumulated mud in a pond

○ Construction of mud solidification treatment

b. Construction by draining water from a reservoir

(a) In-situ treatment method (using cement slurry)

It is necessary to ensure dump truck travelability when excavating and transporting treated soil

① Mud work vehicle

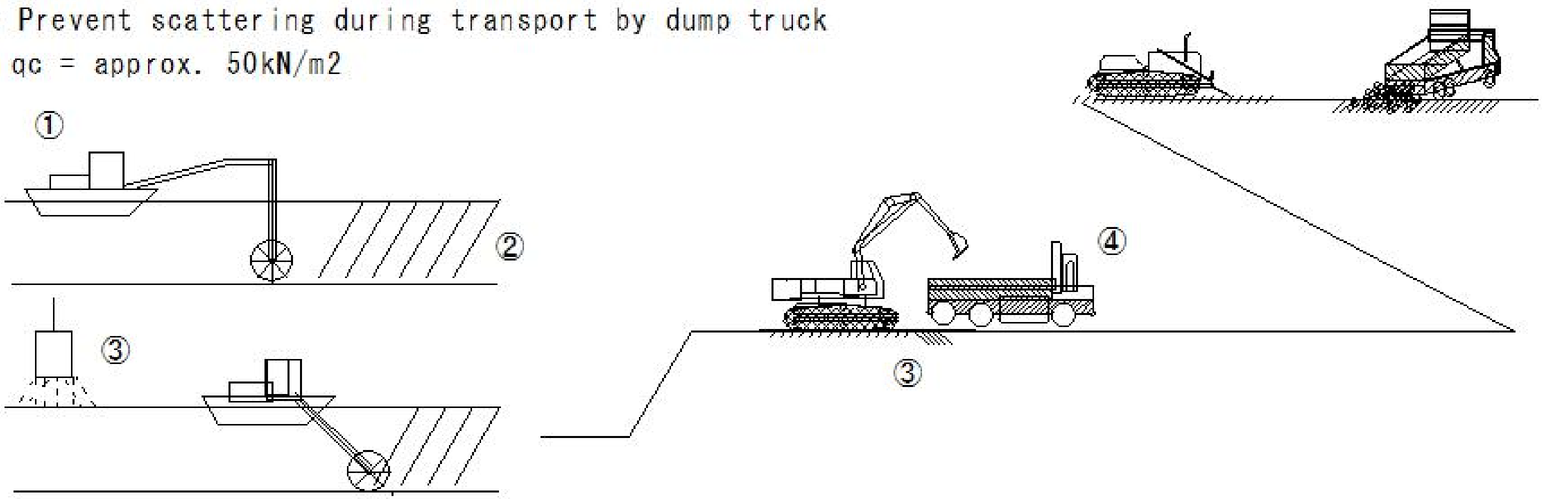
② Improvement thickness: 1.0 to 3.0m possible

③ Target strength is to ensure dump truck travelability

qc = 1200kN/m2 or more

④ Prevent scattering during transport by dump truck

qc = approx. 50kN/m2



(I1739) Reservoir Development

(I1739) Reservoir Development

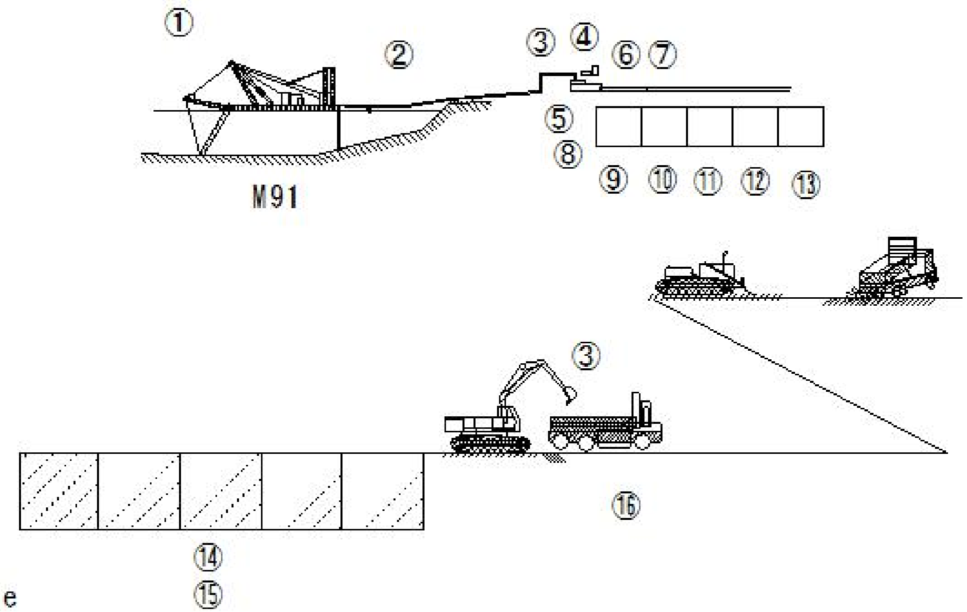
3. Solidification treatment of accumulated mud in a pond

○Construction of mud solidification treatment

b. Construction by draining water from the reservoir

(b) Soil removal and processing method (using cement fragments)

① Mud work boat
② Mud suction pump
③ Mud dumping
④ Material supply device
⑤ Plant
⑥ Silo
⑦ Pressure pump
⑧ Curing pit
⑨ Injection
⑩ Curing 1 day
⑪ Curing 2 days
⑫ Curing 3 days
⑬ Soil transportation
⑭ Curing about 3 days
⑮ Transport with qc = 50kN/m2 or more
⑯ Treated soil spread by disposal site (wetland bulldozer qc = 300kN/m2 or more)



(I1740) Reservoir Development

(I1740) Reservoir Development

5.1 Reservoir renovation work

Figure 5.1.1 Effective use of mud solidification-treated soil

○ Improvement of deformability

(Initially solidified soil → crushed soil, compacted soil)

①Bottom mud

②Dredging of bottom mud

③Solidification treatment (initial solidification soil) - Curing for a certain period (ts)

④Excavation (crushed soil) - Transporting soil (to the embankment position)

⑤Spreading and compaction (crushed soil, converted soil)

⑥Embankment embankment material (checking deformability is important)

⑦Reservoir

⑧Current state of embankment

⑨Foundation

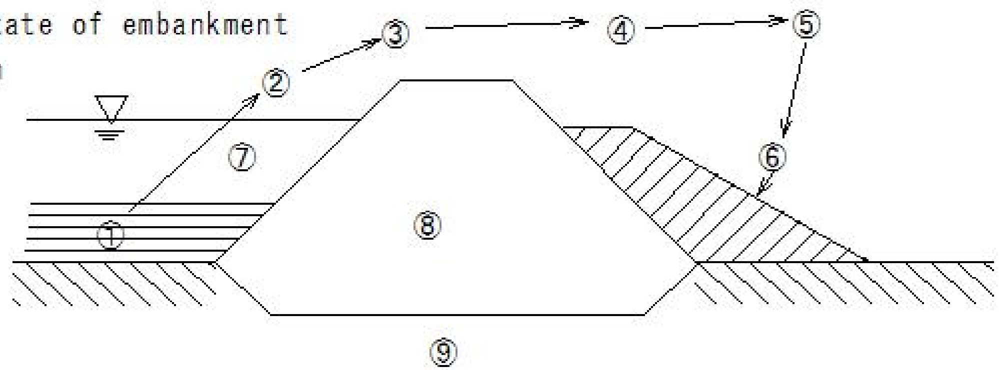


Figure 5.1.1 Effective use of mud solidification-treated soil

(I1741) Reservoir Development

5.1 Reservoir renovation work

Figure 5.1.2 Uses of Crushed Soil and Compacted Soil

1. Embankment Filling Material

① Embankment Raising

② Water-Resistant Zone Floor Excavation Section

③ Current State of Embankment

④ New Embankment

⑤ Foundation

⑥ Embankment with Belt

2. Road Filling Material

⑦ Pavement

⑧ Subgrade and Roadbed Material

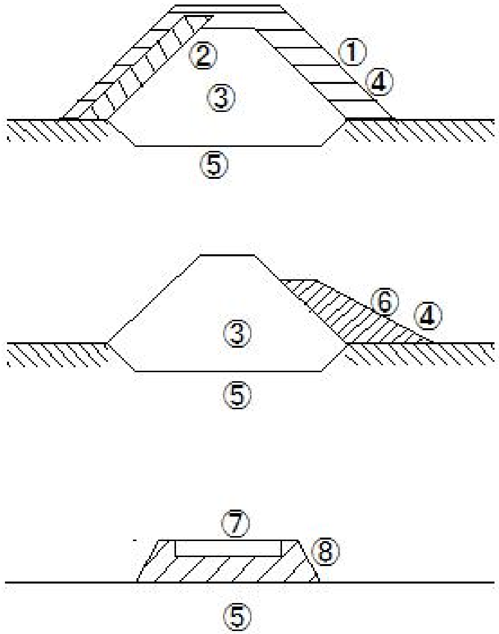


Figure 5.1.2 Uses of Crushed Soil and Compacted Soil

(I1742) Reservoir Development

5.1 Reservoir Renovation Work

Example: Solidification of bottom mud and use as embankment material for renovated reservoir

① Water falling from the reservoir
② Excavation and removal of bottom mud
③ Mixing in the bit
④ Initial solidification curing in the bit
⑤ Crushing of initially solidified soil (prescribed diameter) (bucket crusher)
⑥ Transporting crushed soil (embankment material) to the embankment site (crawler dump)
⑦ Rolling out and leveling crushed soil (backhoe)
⑧ Compaction of crushed soil (crushing and compacting embankment) (bulldozer)

(I1743) Reservoir Development

(I1743) Reservoir Development

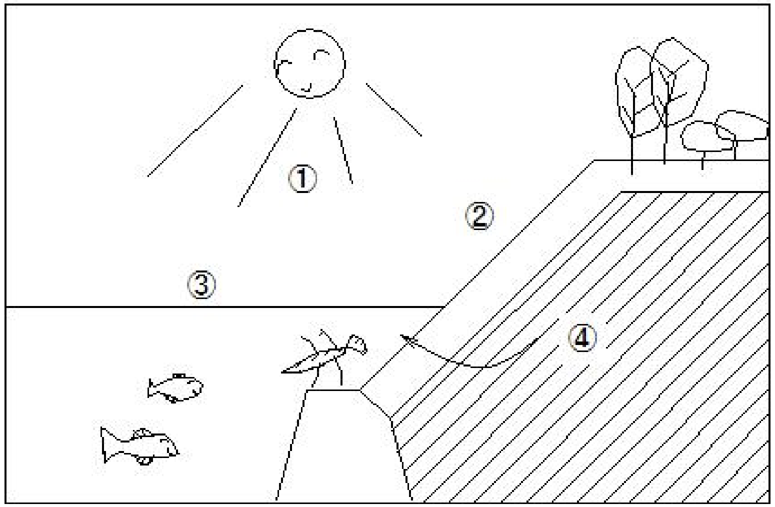
5.1 Reservoir renovation work

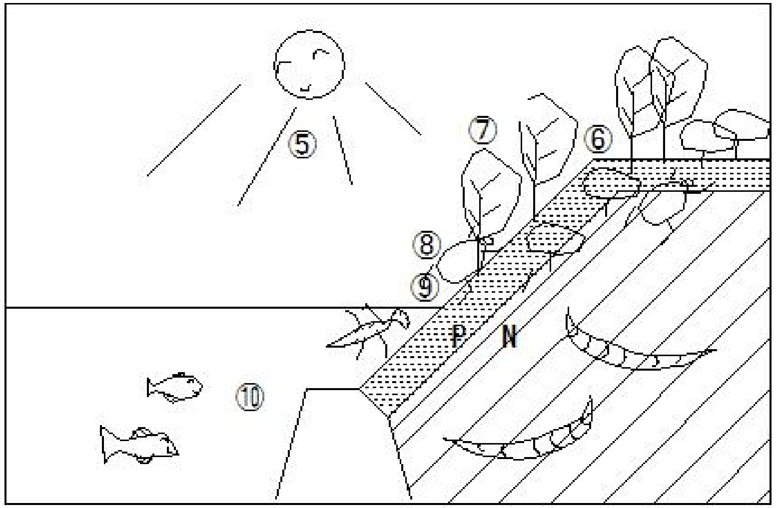
(a) Conventional concrete revetment

① Sunlight
② Discontinuity of ecosystem
③ Rise in water temperature
④ Leaching of alkali

(b) Environmentally friendly revetment method

⑤ Sunlight
⑥ Low-cost natural soil filler
⑦ Suppression of overgrowth
⑧ Terrestrial insects
⑨ Shade around water
⑩ Water purification function





(I1744) Reservoir Development

(I1744) Reservoir Development

5.1 Reservoir renovation work

Figure 5.3.2 Test construction

① Step height
② Surface protection
③ Bench width b
④ Improved soil cross-sectional area Af = Ar + Ac
⑤ Random cross-sectional area Ar
⑥ Water-impermeable group area Ac
⑦ Formwork
⑧ Old embankment

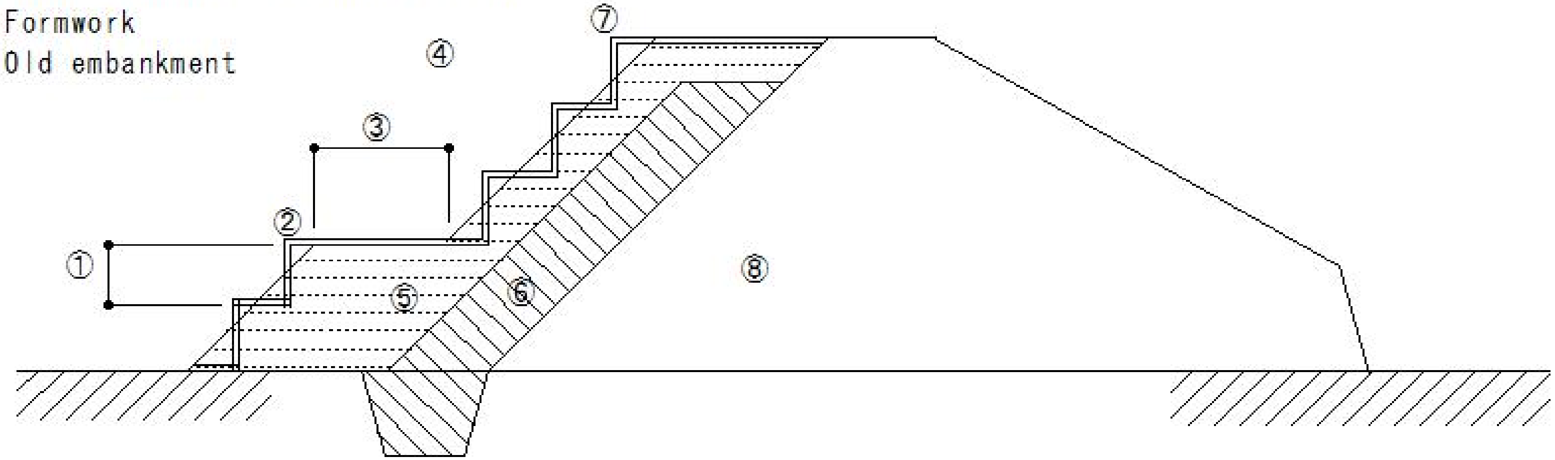


Figure 5.3.2 Test construction

(I1745) Reservoir Development

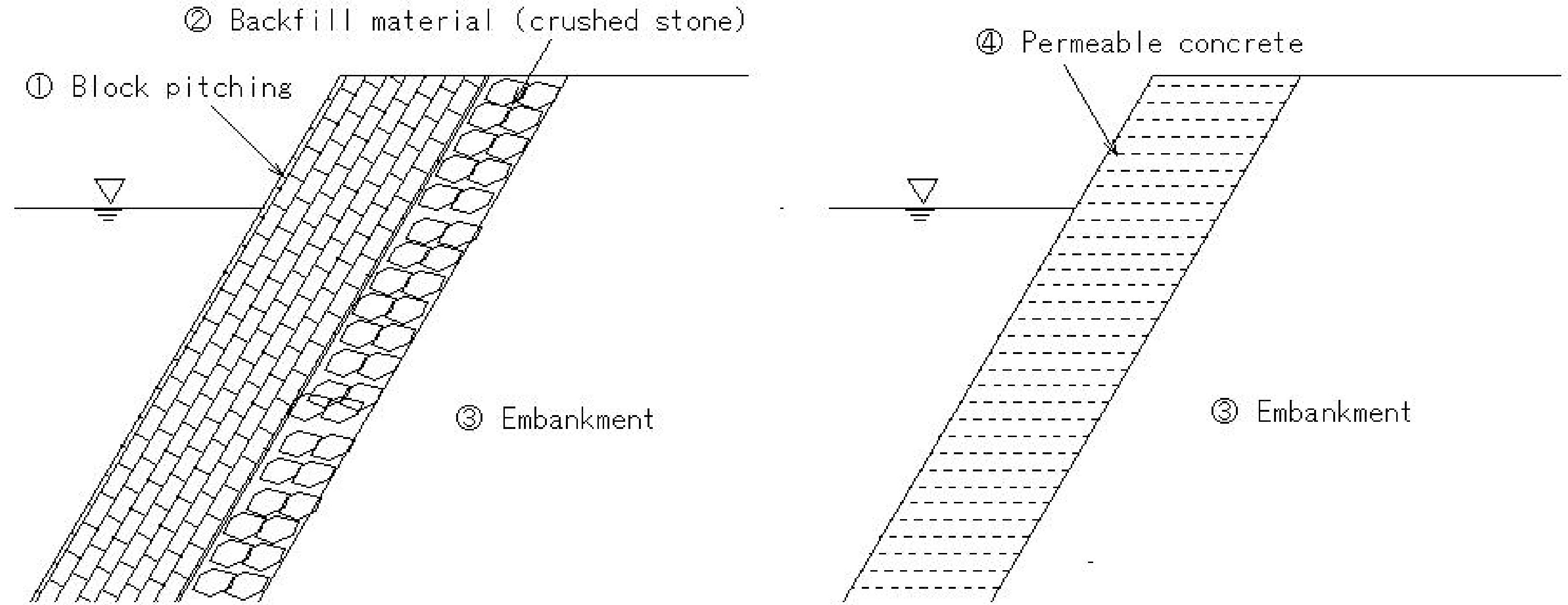
(I1745) Reservoir Development

5.1 Reservoir renovation work

5.4 Cast-in-place permeable concrete

(a) Conventional method

(b) New method

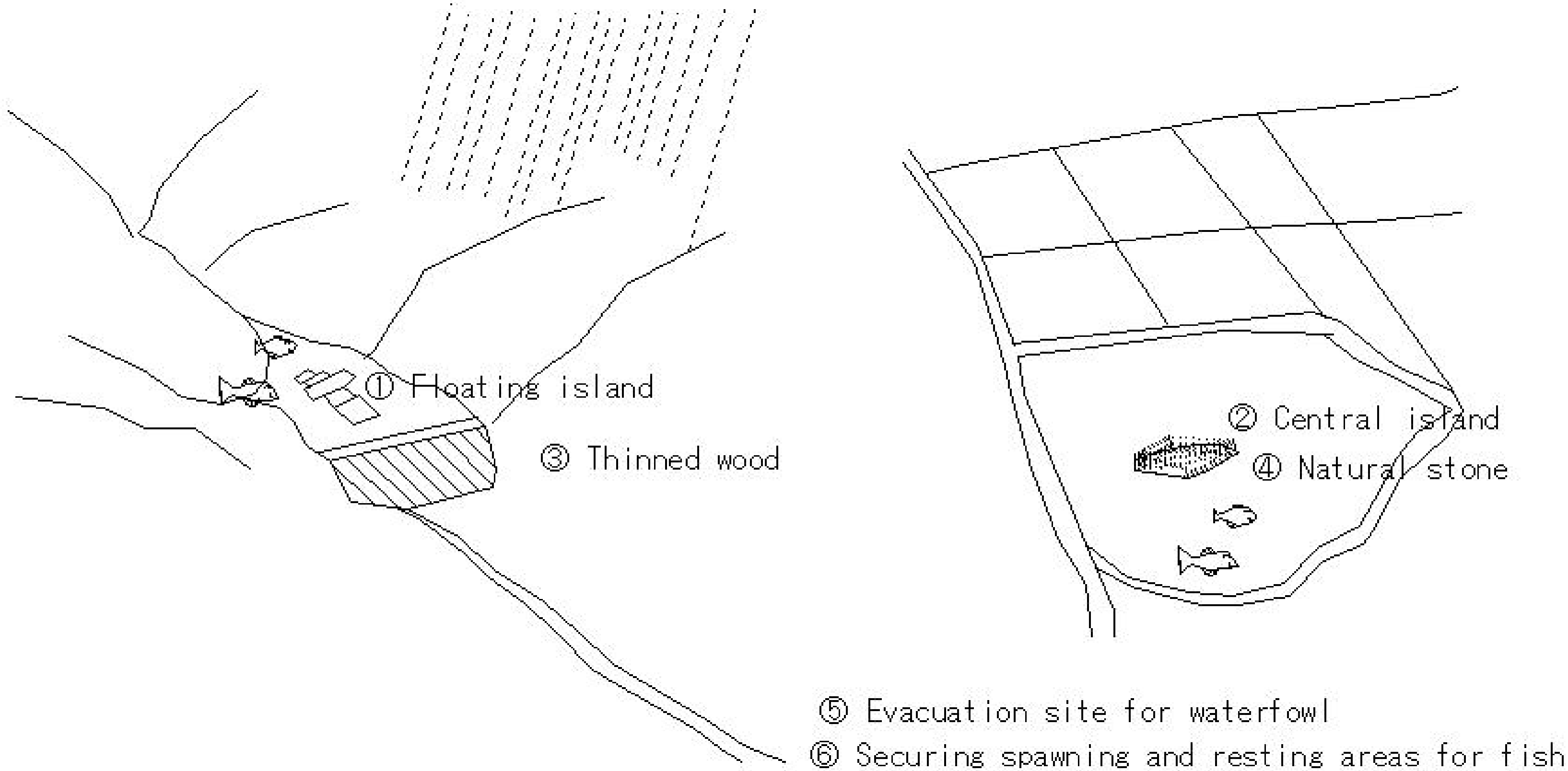


(I1746) Reservoir Development

(I1746) Reservoir Development

6. Construction that considers harmony with the environment

6.1 Consideration of bird and fish habitats



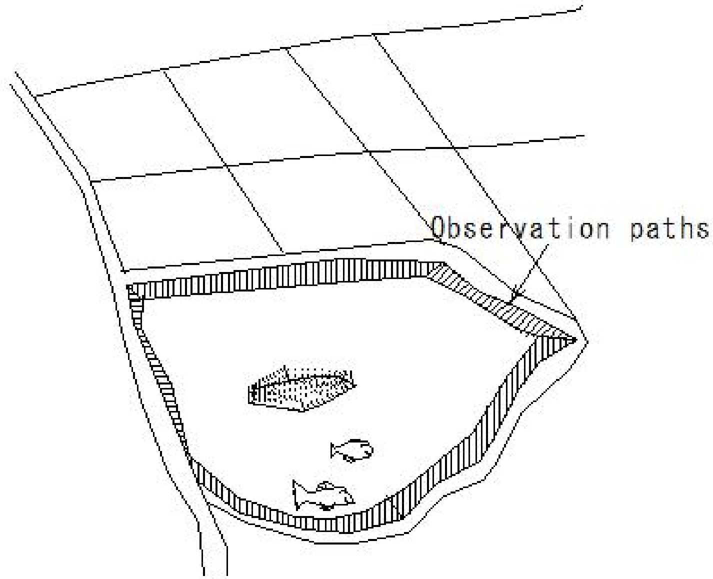
(I1747) Reservoir Development

(I1747) Reservoir Development

6. Construction that considers harmony with the environment

6.2 Preservation of aquatic plants and animals and observation paths

Nature observation paths made from thinned wood



(I1748) Reservoir Development

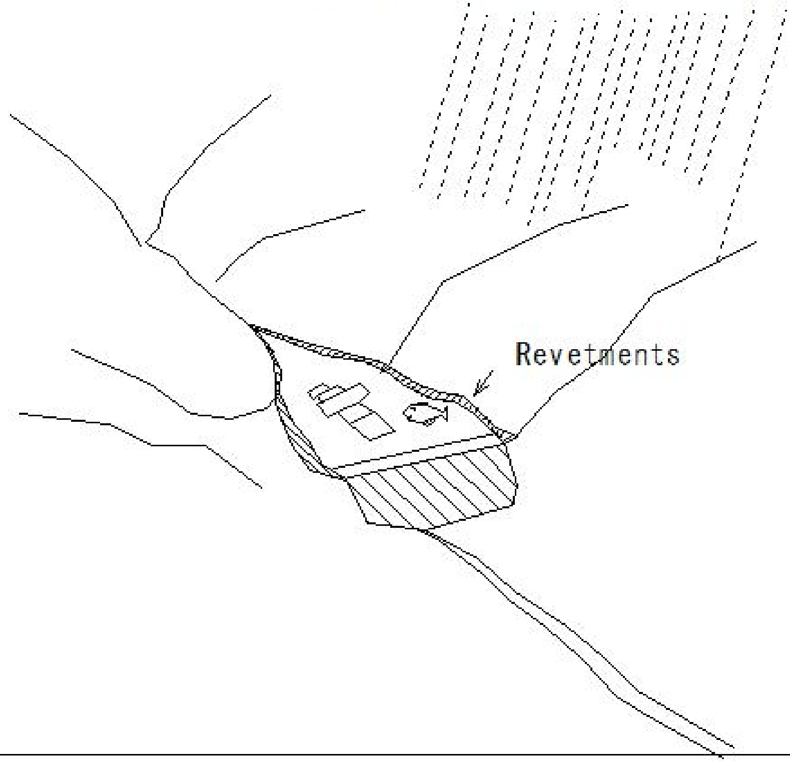
(I1748) Reservoir Development

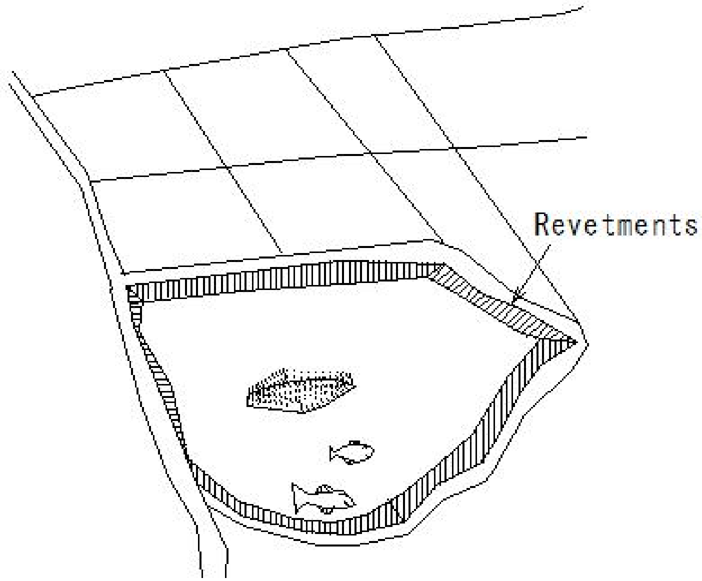
6. Construction that considers harmony with the environment

6.3 Restoration of revetments damaged by wave erosion

① Revetments made from natural materials

② Ensuring habitat and growth space for aquatic organisms





(I1749) Reservoir Development

(I1749) Reservoir Development

6. Construction that considers harmony with the environment

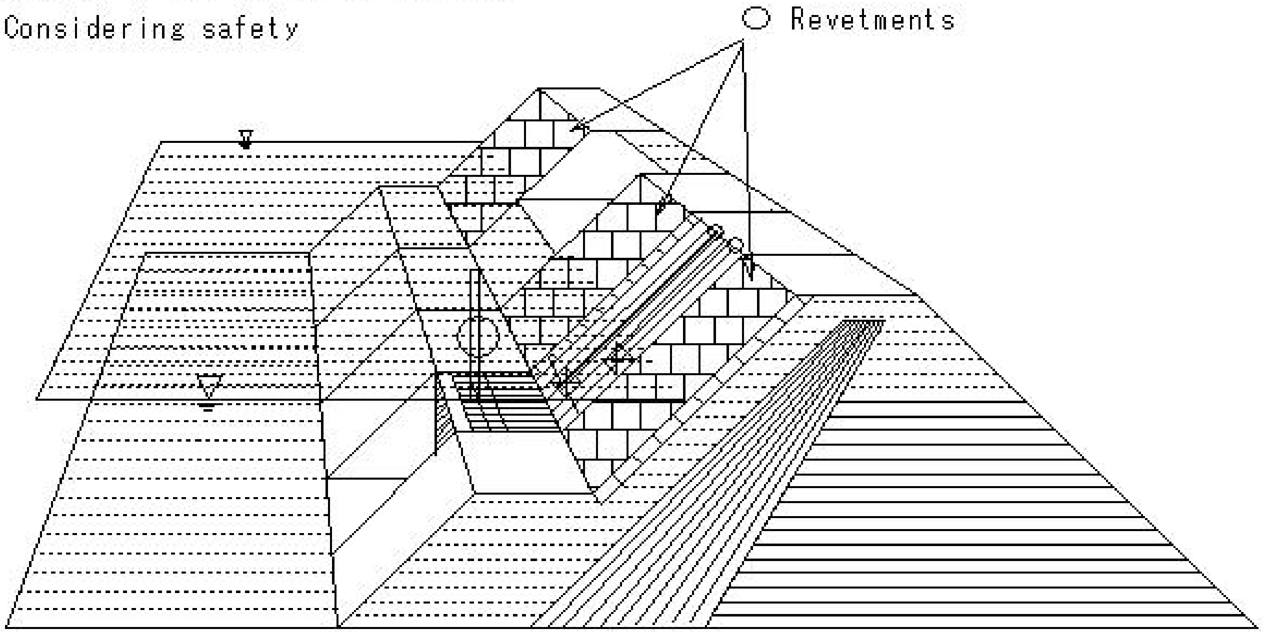
6.4 Revetments that consider ecosystems and safety

○ Revetments

① Rough, porous revetments with an uneven surface

② Ensuring habitat and growth space for small animals

③ Falling accidents - Considering safety



I1382

(I1750) Reservoir Development

(I1750) Reservoir Development

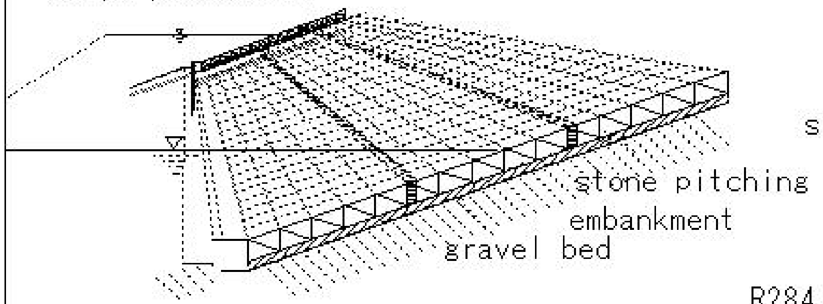
6. Construction that considers harmony with the environment

6.5 Revetments that consider the landscape

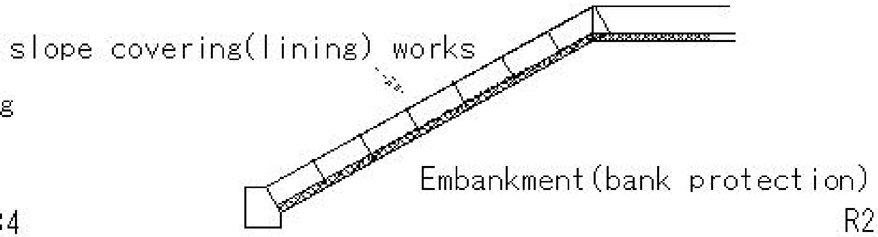
① Revetments made of natural stone

② Revetments with a variety of patterns

stone pitching work
- Embankment slope
- Slope protection

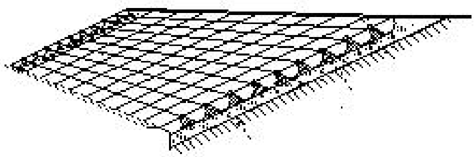


R284



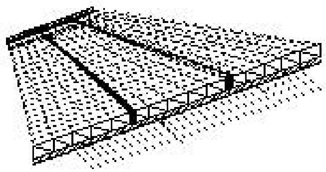
R232

Concrete block pitching



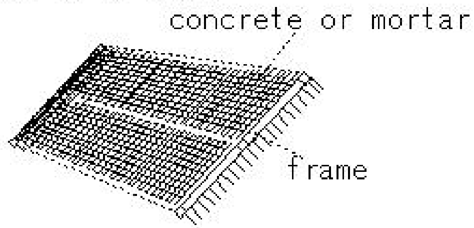
R244

stone pitching work



R284

slope crib work



R584

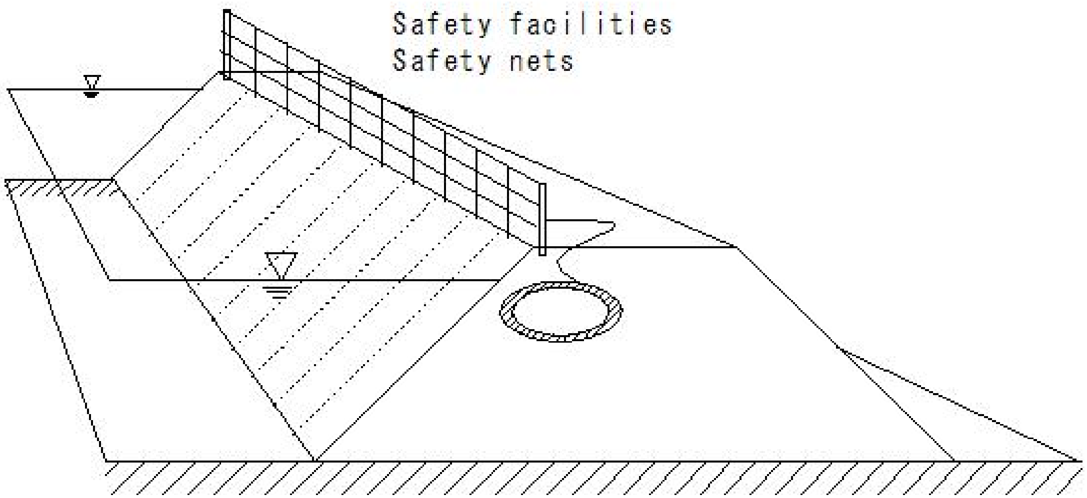
(I1751) Reservoir Development

(I1751) Reservoir Development

6. Construction that considers harmony with the environment

6.6 Safety facilities that use natural materials

① Safety facilities that use thinning materials



I1491

I1520

(I1752) Reservoir Development

(I1752) Reservoir Development

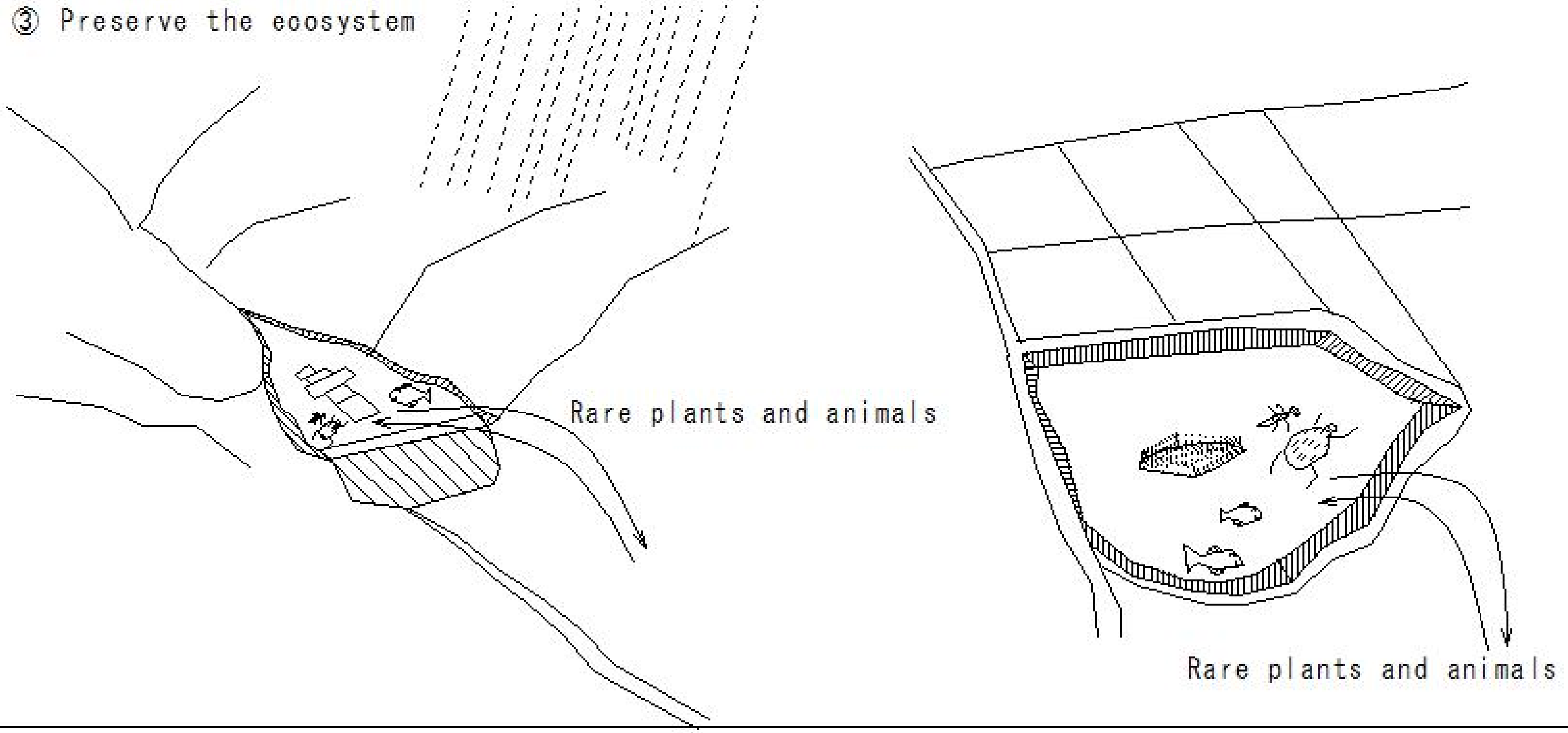
6. Construction that considers harmony with the environment

6.7 Protection of rare plants and animals

① Evacuate and transplant rare plants and animals that inhabit the area during construction

② Re-transplant them after completion

③ Preserve the ecosystem



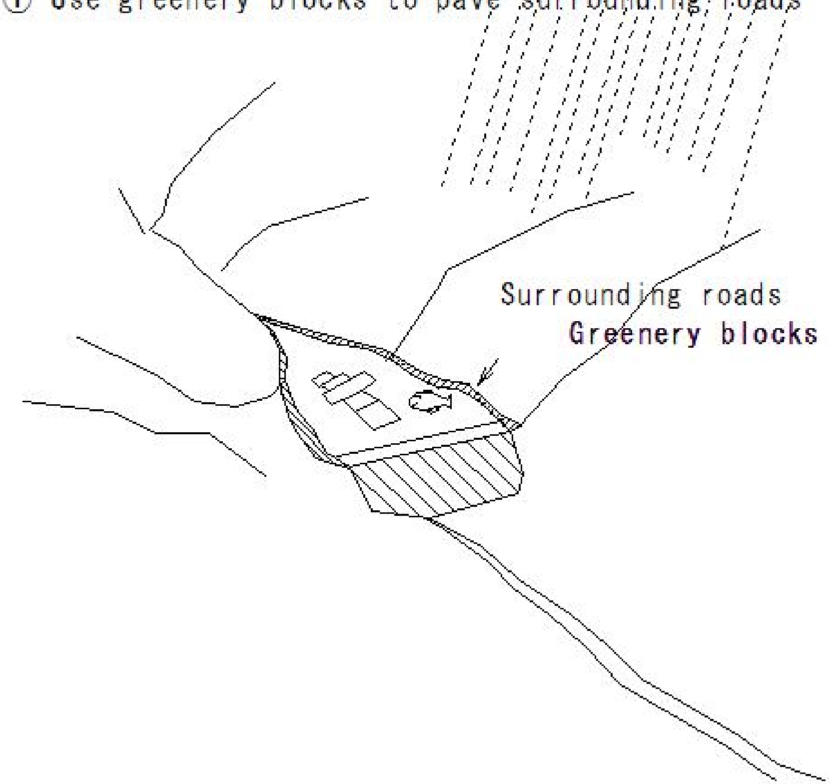
(I1753) Reservoir Development

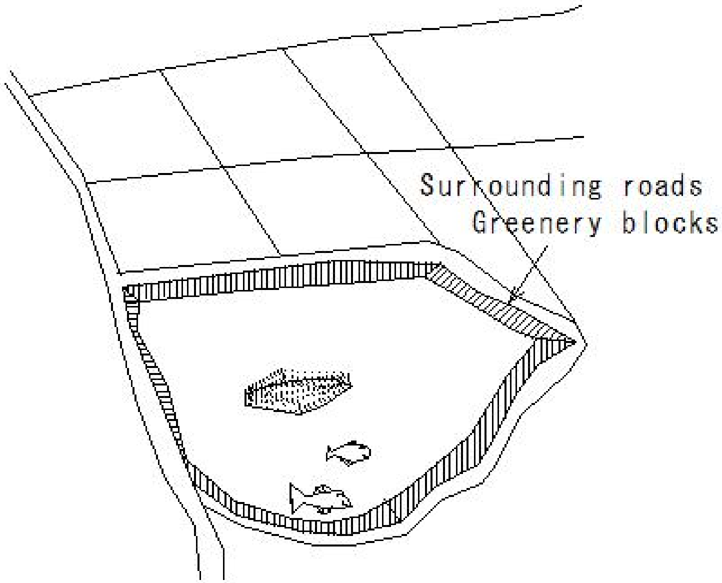
(I1753) Reservoir Development

6. Construction that considers harmony with the environment

6.8 Pavement that considers the landscape

① Use greenery blocks to pave surrounding roads





(I1754) Reservoir Development

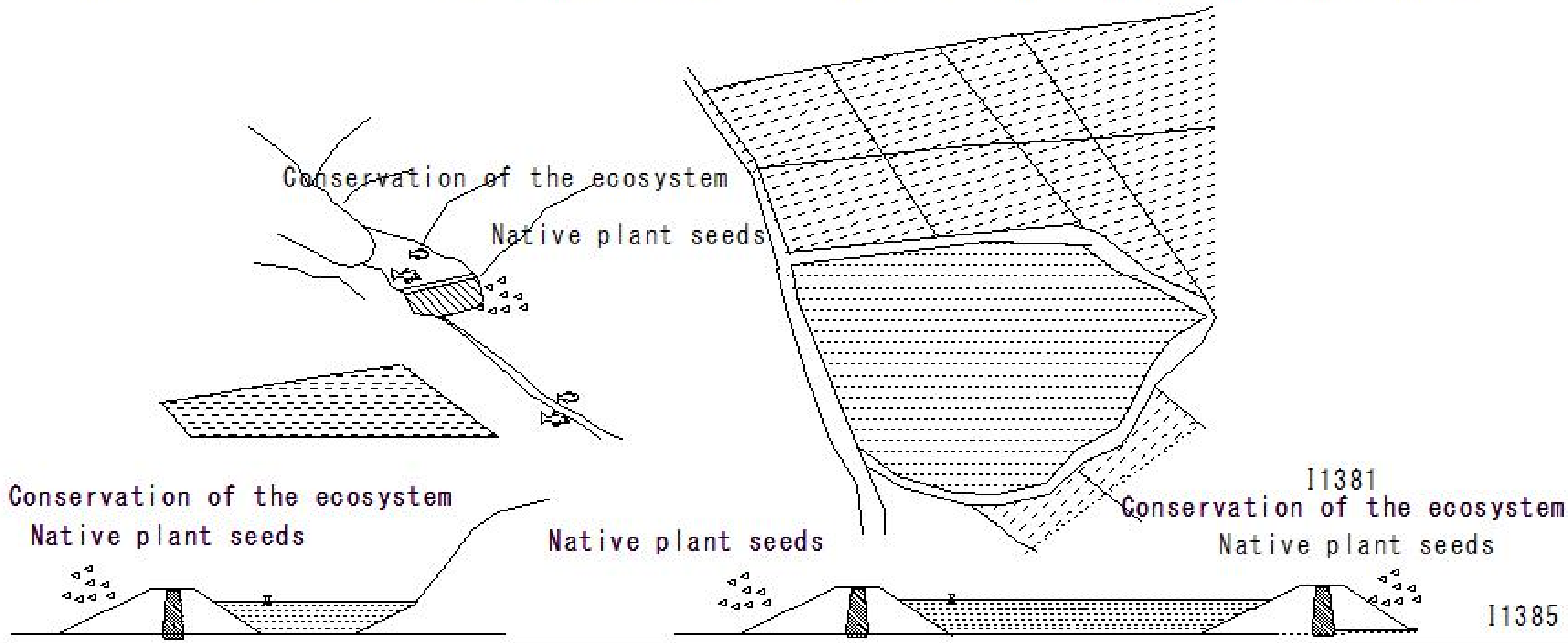
(I1754) Reservoir Development

6. Construction that considers harmony with the environment

6.9 Preservation of native plants on the downstream slope of the embankment

① Secure seeds of native plants on the downstream slope of the embankment in advance, raise seedlings, and plant them after renovation

② Aim to restore natural plants and consider preserving the natural environment and ecosystem



(I1755) Reservoir Development

(I1755) Reservoir Development

9. Earthquake-resistance measures

〇Hardware measures

a: Earthquake motior	① Adding resistance to sliding and deformation	② Reinforcement embankment method
		③ Steel pipe sheet pile method
		④ Embankment reinforcement method
	⑤ Increasing density	⑥ Vibration compaction method
	⑦ Consolidation	⑧ Ground improvement method
b: Liquefaction	⑨ Grain size improvement	⑩ Replacement method
	⑪ Lowering the wet surface (reducing the saturated area)	⑫ Drain method
		⑬ Installation of filter zone
	⑭ Dissipation of pore water pressure	⑮ Columnar drain method
c: Infiltration	⑯ Infiltration suppression at the embankment	⑰ Cross-sectional expansion method
		⑱ Drain method
		⑲ Surface impermeable wall method (Waterproof sheet method)
	⑳ Infiltration suppression at the foundation ground	㉑ Upstream impermeable method (Steel sheet pile method)
		㉒ Blanket method

〇Software measures

① Creation of hazard maps, their release/publication, and decision on evacuation destinations
② Establishment of water storage rules, review of required water storage volume
③ Establishment of monitoring/alarm/reporting systems
④ Implementation of disaster prevention/evacuation drills
⑤ Preparation of emergency materials for emergencies, establishment of emergency discharge works, conclusion of disaster prevention agreements
⑥ Establishment of BCP, strengthening of management system

Figure 9.1 Earthquake resistance construction

(I1756) Reservoir Development

(I1756) Reservoir Development

9. Earthquake resistance measures

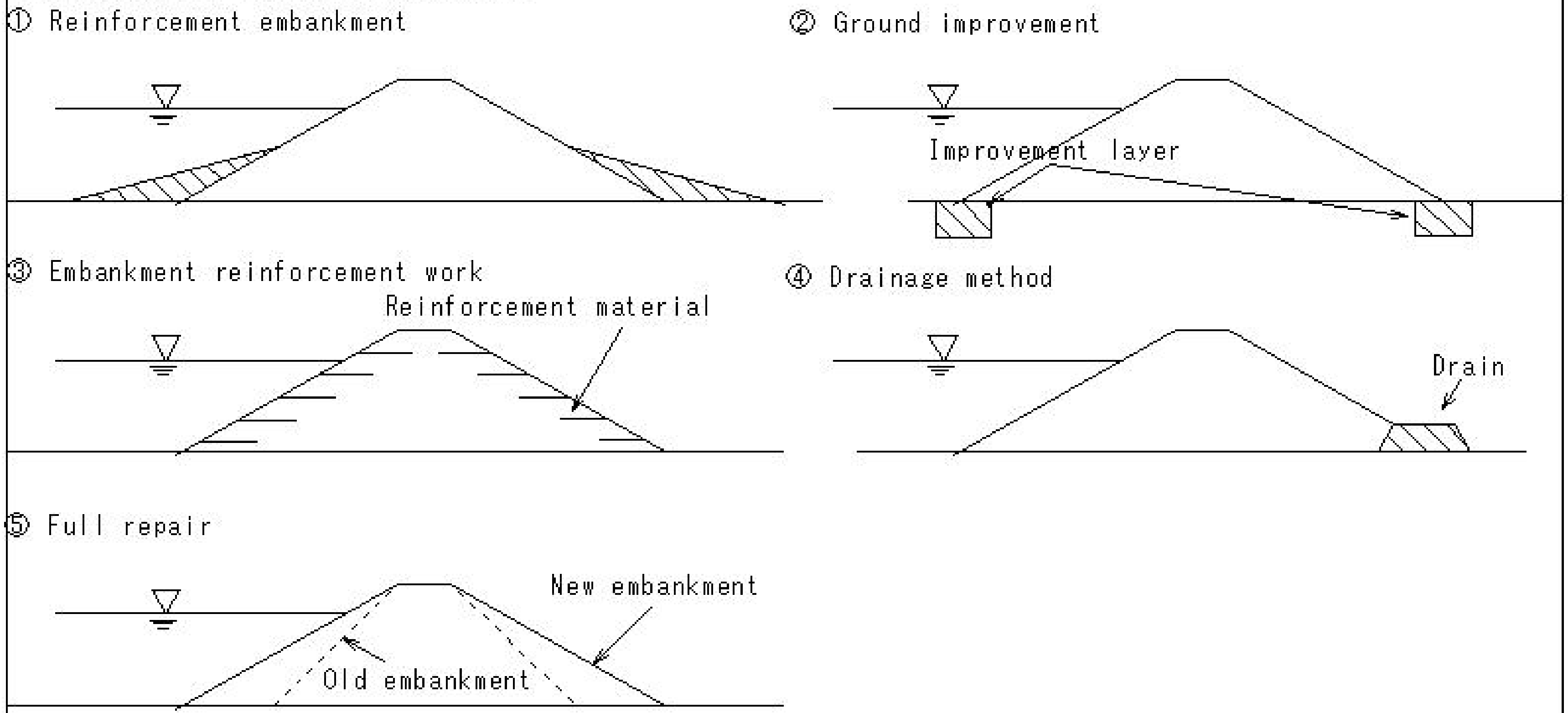


Figure 9.1 Major earthquake resistance measures for reservoirs

(I1757) Abolition of agricultural reservoirs

(I1757) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

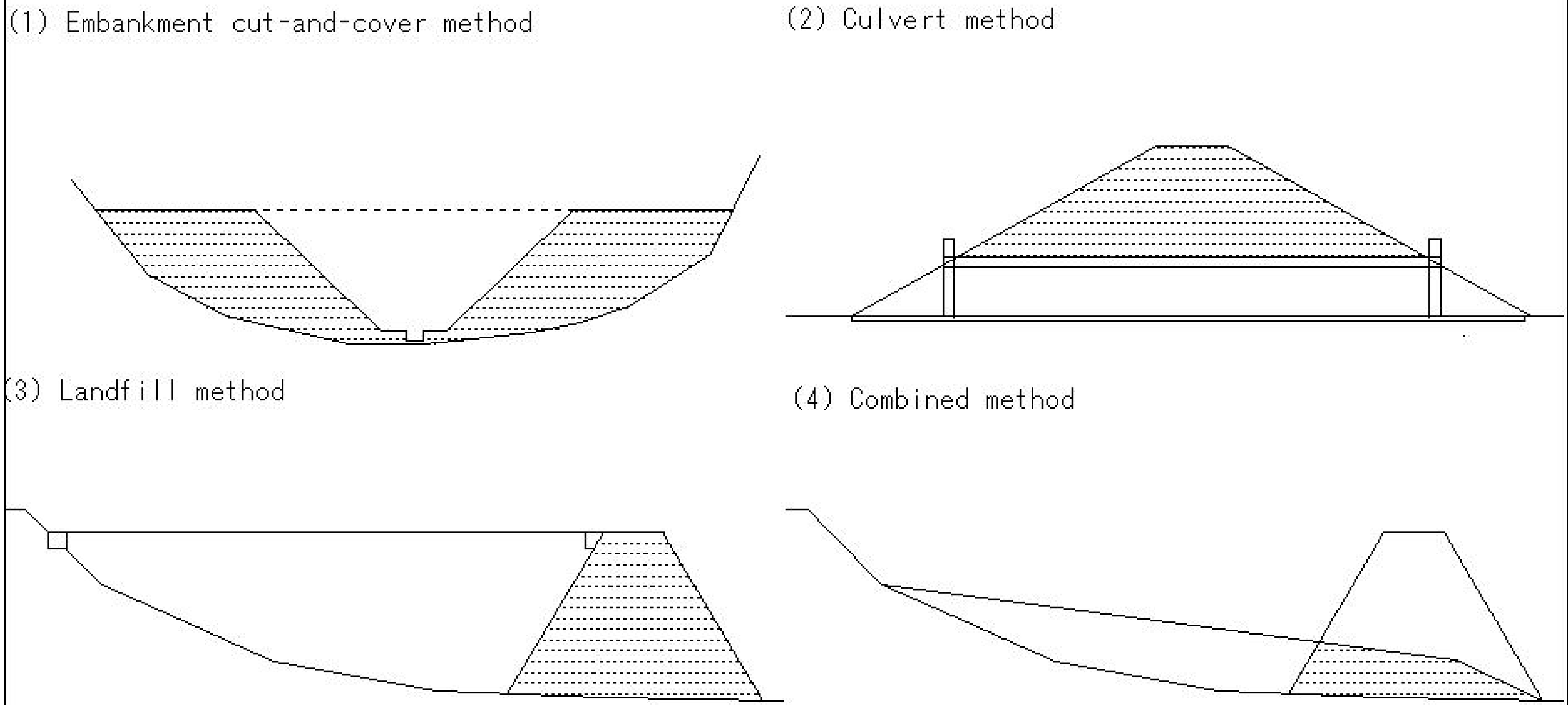


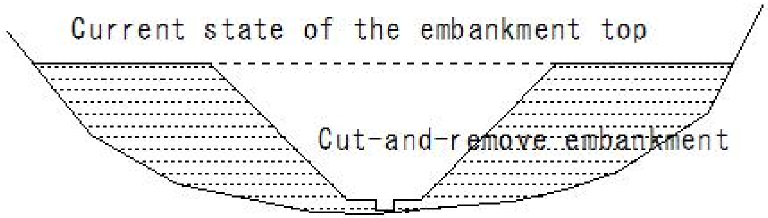
Table 3.1 Construction methods for decommissioning reservoirs

(I1758) Abolition of agricultural reservoirs

(I1758) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs
(1) Embankment cut-and-cover method



○Overview of the method
A method in which part or all of the embankment is cut, causing the reservoir to lose its water storage function.

○Overview
Current state of the embankment top Cut-and-remove embankment

○Disaster prevention
The risk of embankment collapse can be eliminated. ・Even if measures are taken to prevent soil from escaping, attention must be paid to the accumulation of soil over

○Harmony with the environment
As an environmentally friendly measure, it is possible to leave some water area by making the bottom of the induction channel higher than the deepest part of the

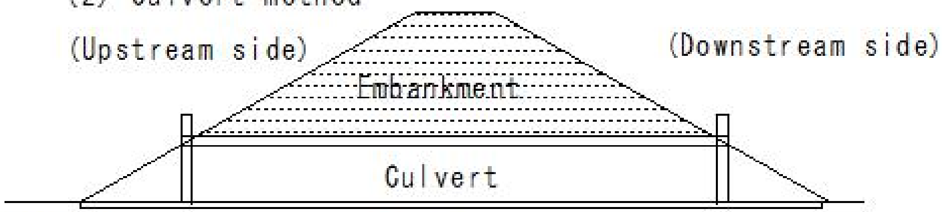
(I1759) Abolition of agricultural reservoirs

(I1759) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

(2) Culvert method



○Overview of the method

This method involves installing a culvert in the current embankment, eliminating the reservoir's water storage function.

○Overview

(Upstream side) (Downstream side) Embankment Culvert

○ Economic efficiency

Varies greatly depending on local conditions, such as driftwood countermeasures.

○Disaster prevention

The risk of the embankment collapsing is reduced, but since there is a risk of the culvert being blocked by driftwood, etc., it is necessary to establish a management

・Even if measures are taken to prevent sediment from escaping, attention must be paid to the accumulation of sediment over time.

○Harmony with the environment

As an environmentally friendly measure, it is possible to leave some water areas by making the bottom of the culvert higher than the deepest part of the reservoir.

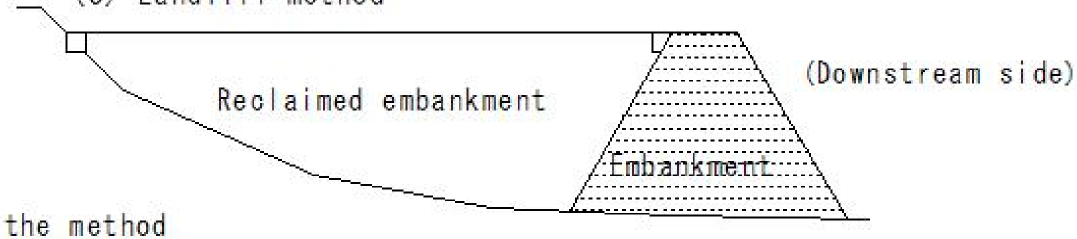
(I1760) Abolition of agricultural reservoirs

(I1760) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

(3) Landfill method



○Overview of the method

A method of filling up a reservoir with soil from the embankment or brought in soil, etc., to eliminate its water storage function

○ Economic efficiency

Since it requires improvement of the sedimentary soil in the pond, surface drainage facilities, and underground drainage facilities, it is generally more expensive than the embankment excavation method.

○Disaster prevention

- The risk of embankment collapse can be eliminated.
- In order to ensure the stability of the remaining embankment and the entire reclaimed embankment, measures such as cutting the old embankment and slope

○Harmony with the environment

Since the reservoir will be filled in, it is difficult to preserve the water area as an environmentally friendly measure.

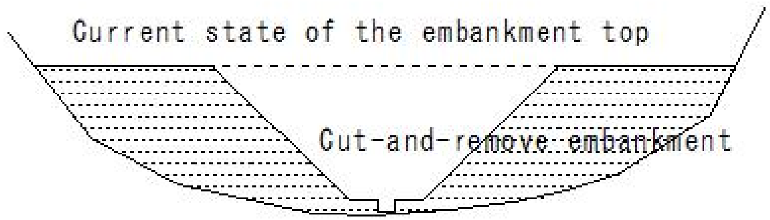
(I1761) Abolition of agricultural reservoirs

(I1761) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

(1) Embankment cut-and-cover method



① The embankment excavation method is a method in which part or all of the embankment is excavated, causing the reservoir to lose its water storage function.

② It has a direct effect on eliminating the risk of embankment collapse, which is the top priority issue, and is generally more economical than landfill or culvert methods, making it the most basic method for reservoir decommissioning work.

③ Even if measures are taken to prevent sediment from running off, attention must be paid to the accumulation of sediment over time.

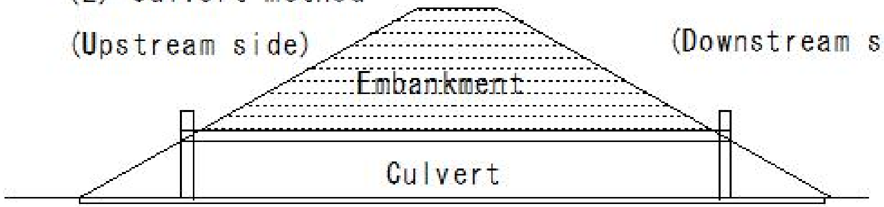
I1758

(I1762) Abolition of agricultural reservoirs

(I1762) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs



① Culvert method is a method in which a culvert is installed in the current embankment, causing the reservoir to lose its water storage function

② Culvert method has the risk of the water level rising due to the blockage of the culvert by driftwood, etc., and overflowing the embankment

③ Ensure an appropriate cross section of the culvert

④ A management system will be established, such as establishing a maintenance plan to ensure proper management on a daily basis.

(I1763) Abolition of agricultural reservoirs

(I1763) Abolition of agricultural reservoirs

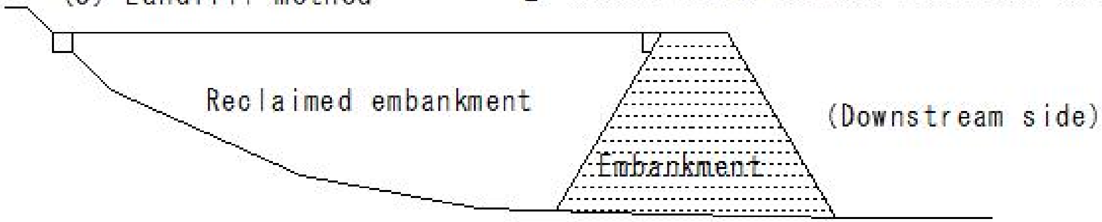
Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

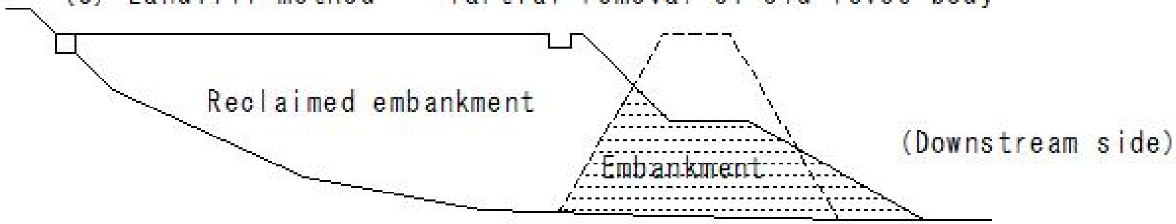
① Reclaiming reservoir with excavated soil or brought-in soil

② Method to eliminate reservoir's water storage function

(3) Landfill method



(3) Landfill method Partial removal of old levee body



③ Improvement of sedimentary soil in reservoir

④ In case of surface drainage facilities and underground drainage facilities are required

⑤ Consider necessary measures such as partial removal of old levee body (cutting, shaping slope)

I1760

(I1764) Abolition of agricultural reservoirs

(I1764) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

(4) Composite construction method

・Composite construction method of dam excavation and fill-in

① A reservoir with a small full water area and a steep bottom slope, such as a valley pond

② A composite construction method of dam excavation and fill-in using excavated soil

③ Cases that are economical and excellent for maintenance after abolition

(4) Combined method

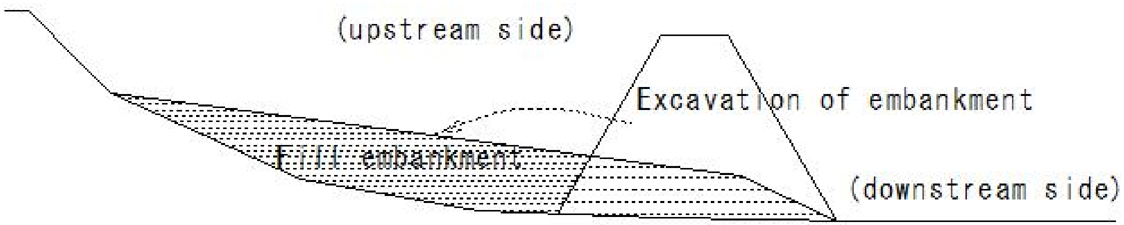


Figure 3.5 Composite construction method of dam excavation and fill-in

I1757

(I1765) Abolition of agricultural reservoirs

(I1765) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

(Longitudinal image)

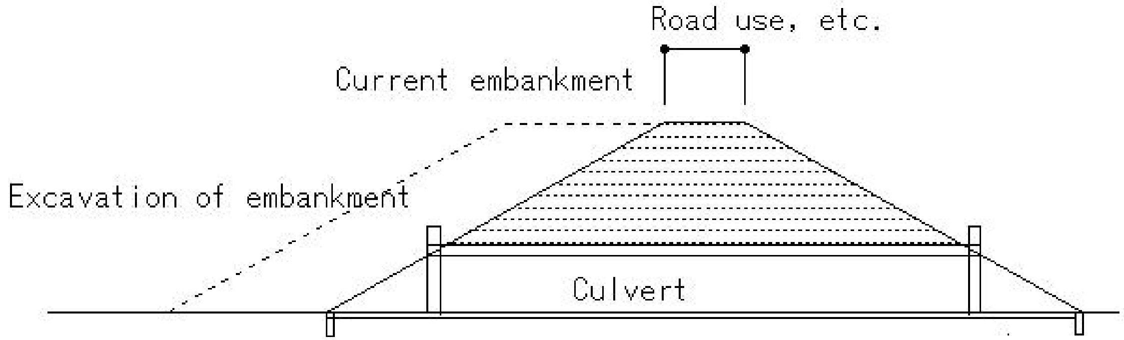


Figure 3.6 Combined method of embankment excavation and culvert construction

・Combined method of embankment excavation and culvert construction

①In case of the width of the embankment crest is very wide and part of the embankment crest is used as a road

②Instead of making the entire embankment crest a culvert

③A combined method in which a culvert is installed only in the road area and the other areas are excavated

(I1766) Abolition of agricultural reservoirs

(I1766) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

(Cross-section image of embankment excavation)

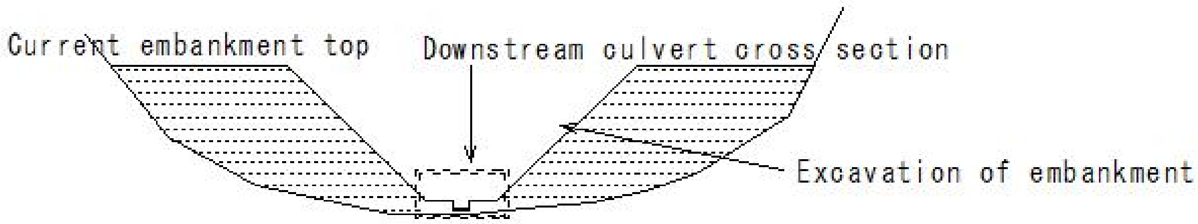


Figure 3.6 Combined method of embankment excavation and culvert construction

・Combined method of embankment excavation and culvert construction

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③A combined method in which a culvert is installed only in the road area and the other areas are excavated

(I1767) Abolition of agricultural reservoirs

(I1767) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Construction methods for decommissioning reservoirs

(Image of the cross section of the culvert)

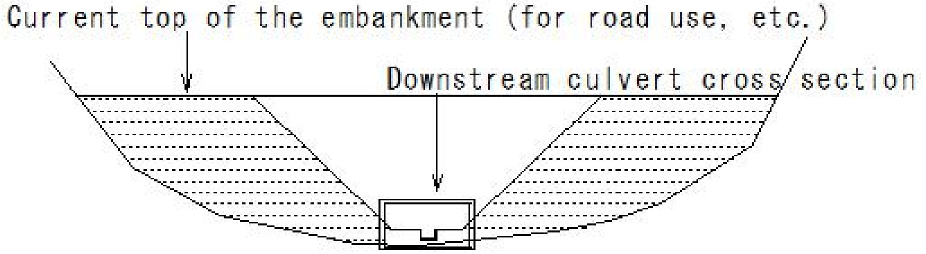


Figure 3.6 Combined method of embankment excavation and culvert construction

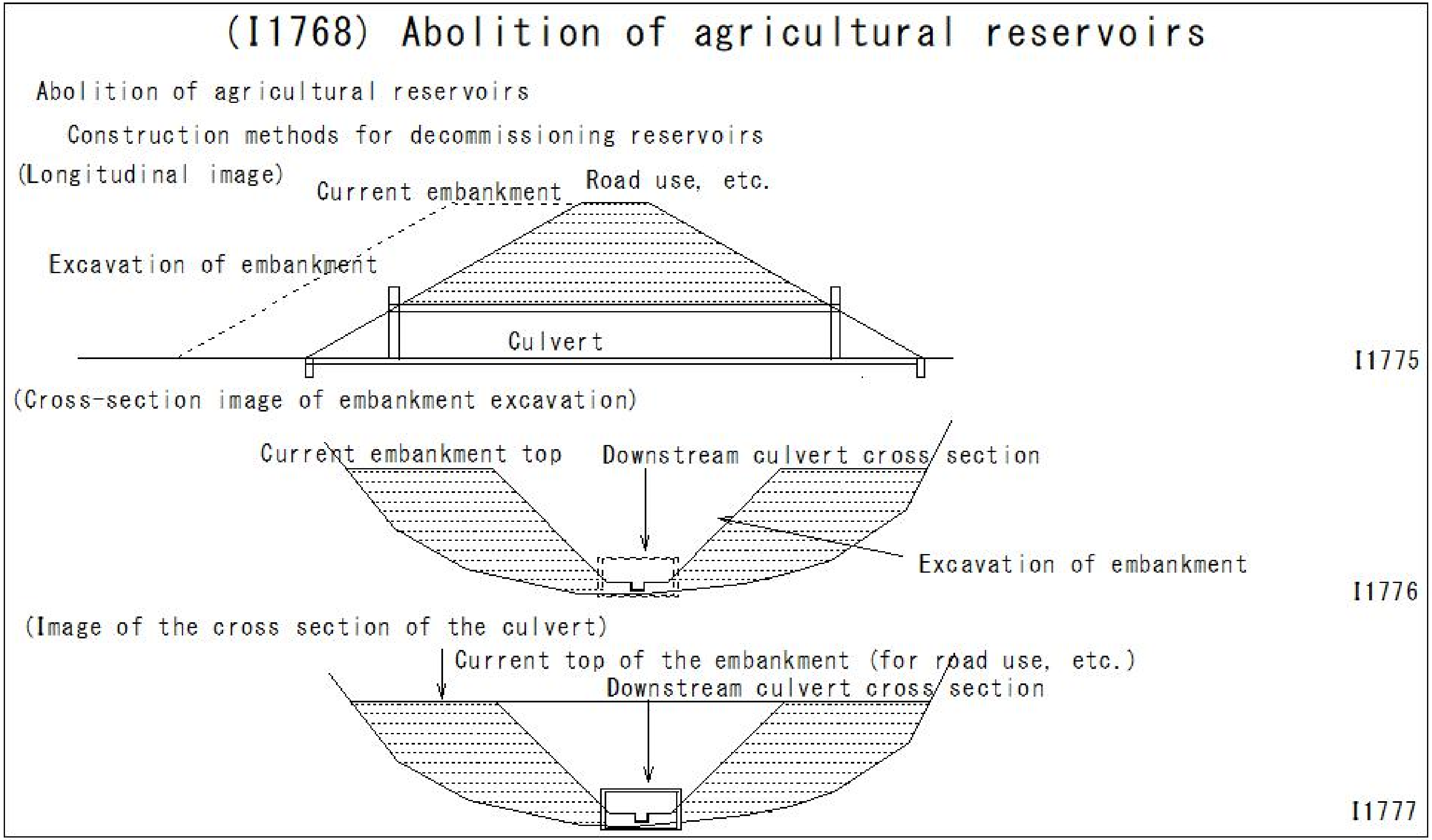
・Combined method of embankment excavation and culvert construction

①In case of the width of the embankment crest is very wide and part of the embankment crest is used as a road

②Instead of making the entire embankment crest a culvert

③A combined method in which a culvert is installed only in the road area and the other areas are excavated

(I1768) Abolition of agricultural reservoirs



(I1769) Abolition of agricultural reservoirs

(I1769) Abolition of agricultural reservoirs

Abolishment of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of the cut-and-cover embankment method

4.1 Structure of the cut-and-cover embankment method and definition of terms

The structure of the cut-and-cover embankment method and definition of terms are as follows.

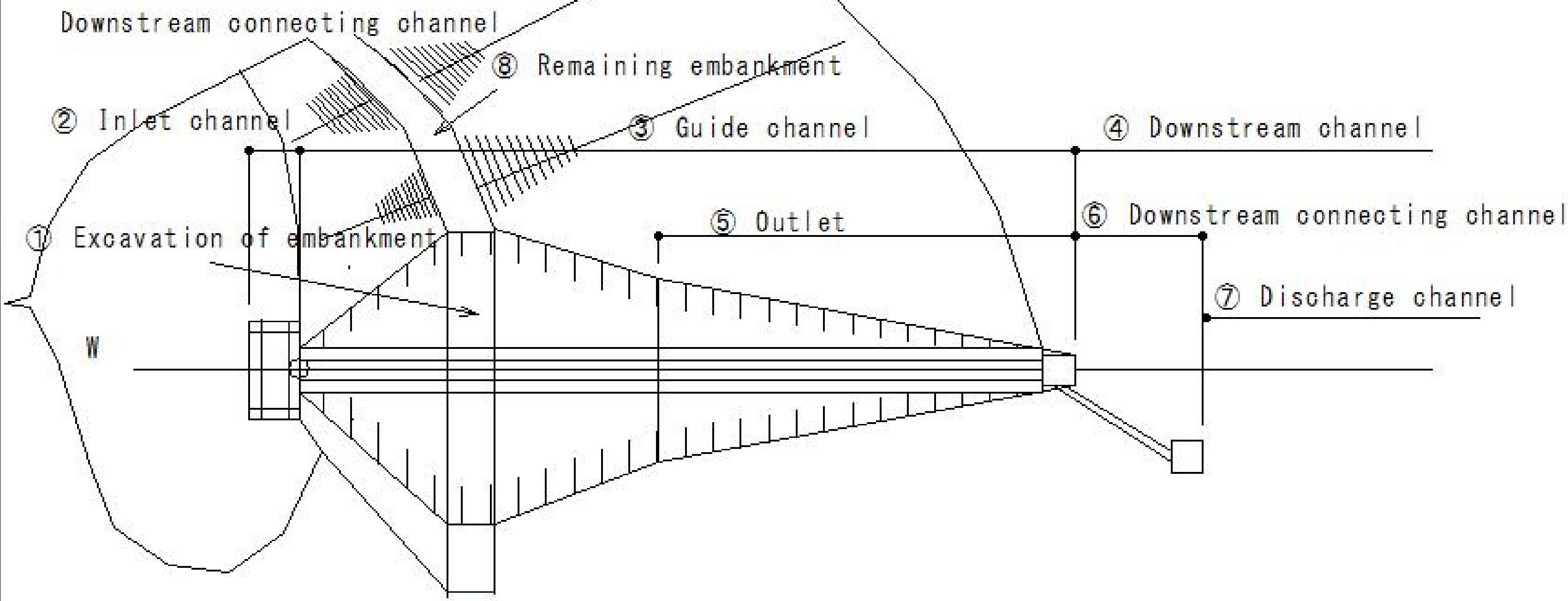


Figure 4.1.1 Names of each component of the cut-and-cover embankment method

(I1770) Abolition of agricultural reservoirs

(I1770) Abolition of agricultural reservoirs

Abolishment of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of the cut-and-cover embankment method

4.1 Structure of the cut-and-cover embankment method and definition of terms

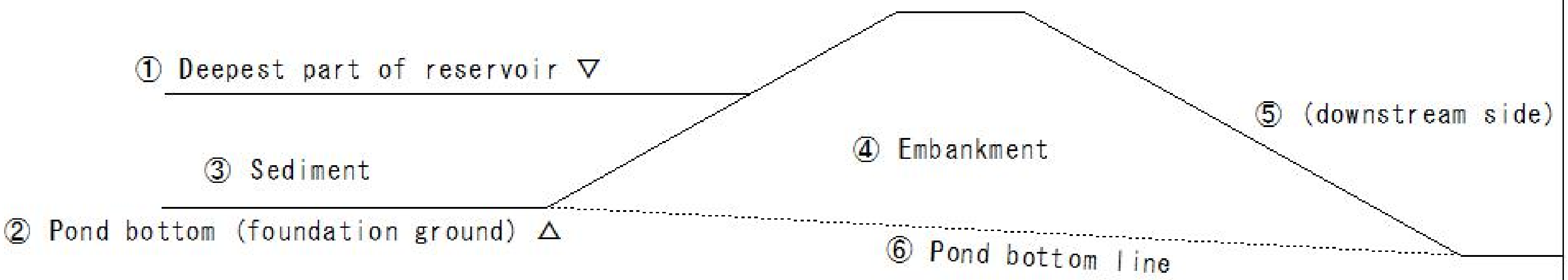


Figure-4.1.2 Deepest part of reservoir

(I1771) Abolition of agricultural reservoirs

(I1771) Abolition of agricultural reservoirs

Abolishment of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of the cut-and-cover embankment method

4.1 Structure of the cut-and-cover embankment method and definition of terms

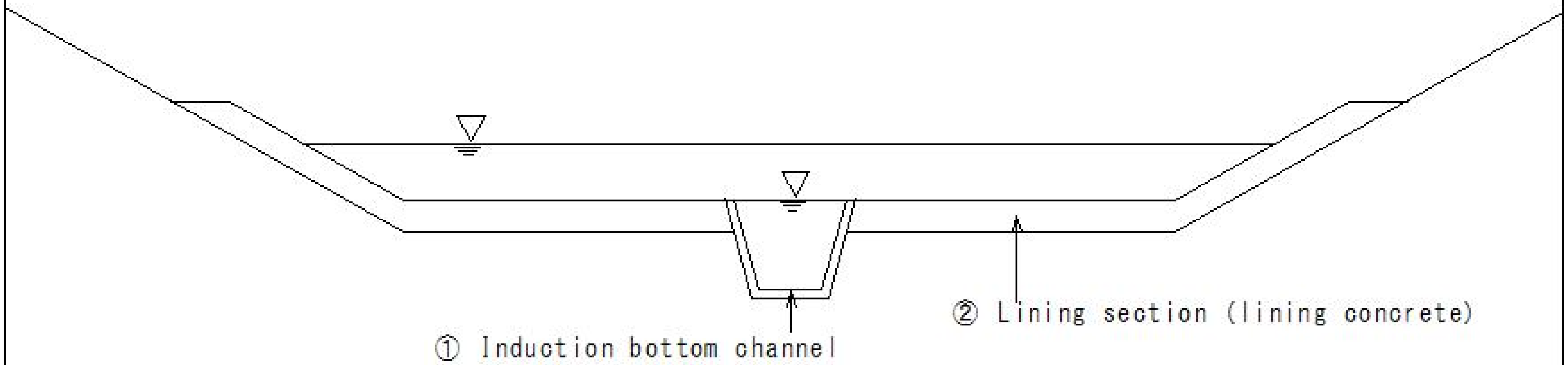


Figure 4.1.3 Names of the parts of the induction channel

(I1772) Abolition of agricultural reservoirs

(I1772) Abolition of agricultural reservoirs

Abolishment of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of the cut-and-cover embankment method

4.2 Consideration of embankment excavation position and induction channel bottom height

The embankment excavation position and induction channel bottom height are set based on the following items, taking into account the field survey, etc.

a Smooth attachment to the drainage channel.

b Stable slope of the excavation slope can be ensured.

c Removal of residual water at the bottom of the pond (prevention of drowning accidents, etc.)

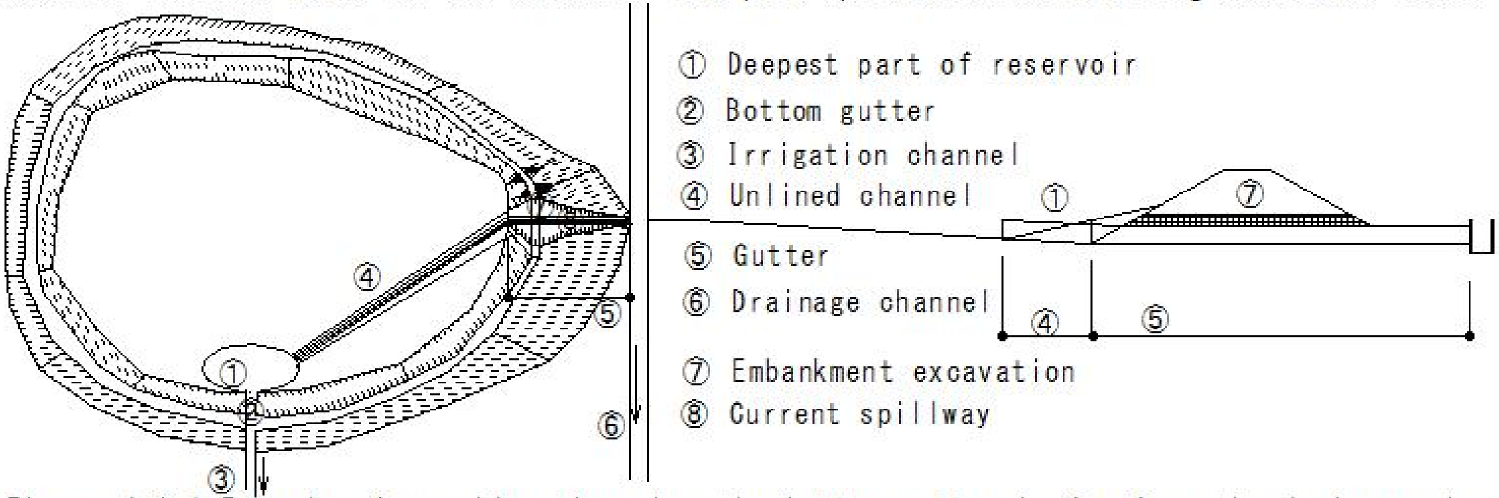


Figure 4.2.1 Example of consideration when the bottom gutter is far from the drainage channel

(I1773) Abolition of agricultural reservoirs

(I1773) Abolition of agricultural reservoirs

Abolishment of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of the cut-and-cover embankment method

4.2 Consideration of embankment excavation position and induction channel bottom height

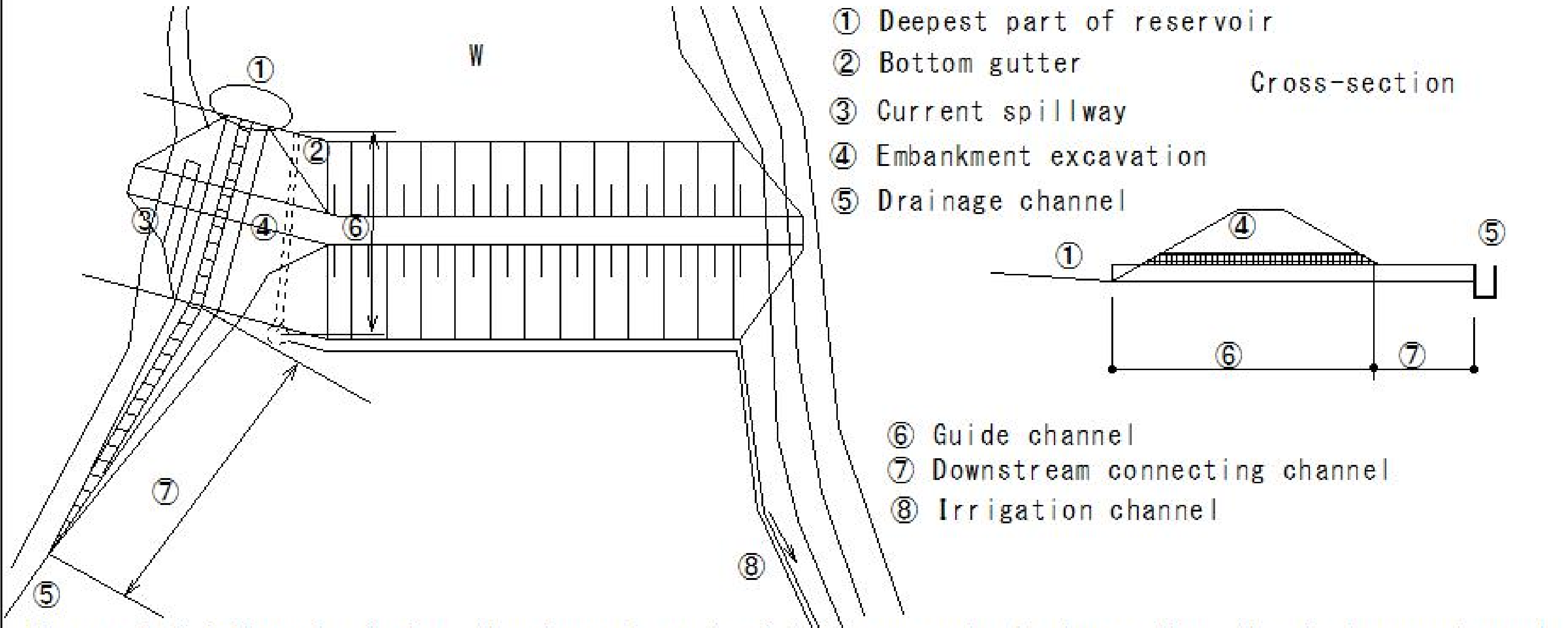


Figure-4.2.2 Example 1 when the deepest part of the reservoir is lower than the drainage channel: Correction of longitudinal gradient

(I1774) Abolition of agricultural reservoirs

(I1774) Abolition of agricultural reservoirs

Abolishment of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of the cut-and-cover embankment method

4.2 Consideration of embankment excavation position and induction channel bottom height

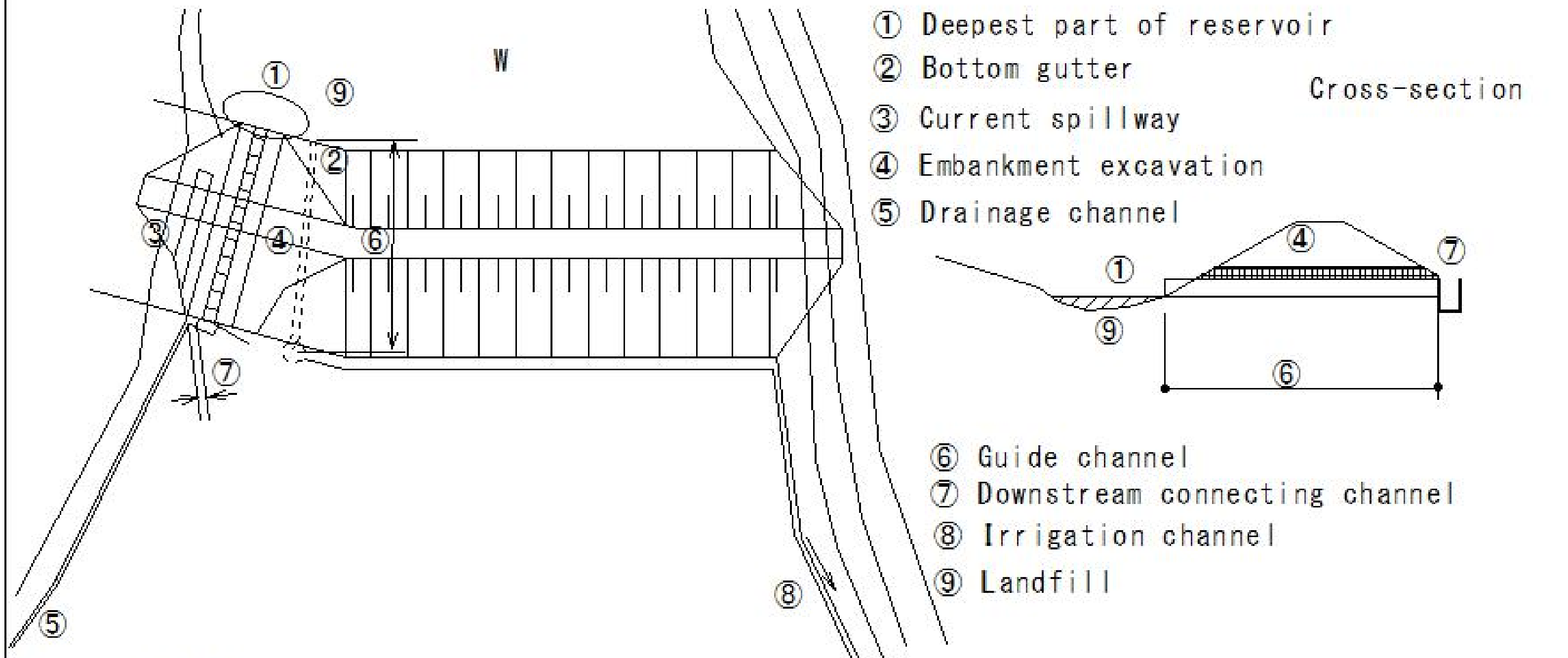


Figure 4.2.3 In case of the deepest part of the reservoir is lower than the drainage channel:
Part of the deepest part of the reservoir bottom is filled in

(I1775) Abolition of agricultural reservoirs

(I1775) Abolition of agricultural reservoirs
Abolition of agricultural reservoirs
Reservoir abolition construction method
Chapter 4 Design of embankment cut-and-cover construction method
(2) Slope gradient of cut-and-cover section

Table 4.3.1 Slope gradient of cut-and-cover section

Excavation height H	Slope gradient of cut-and-cover
5 m or less	1.5 to 1.8
5 to 15 m	1.8 to 2.0

(I1775) Abolition of agricultural reservoirs

① Width of the bottom of the cut
▽② Top of the embankment
▽③ Deepest part of the reservoir
④ Guide bottom channel

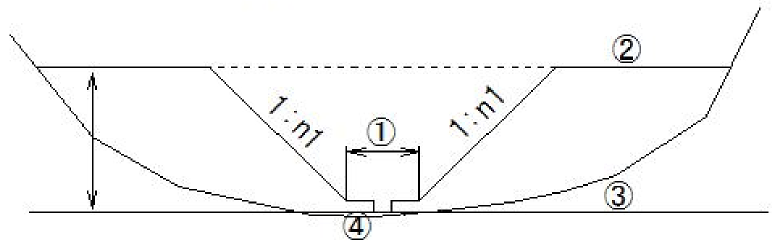


Figure 4.3.1 Standard cross section of the cut-off section of the embankment

(I1776) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

▽① Embankment top

② Cut-and-cover bottom width

③ Ground stability gradient (cut slope)

▽④ Deepest part of reservoir

⑤ Guide bottom waterway

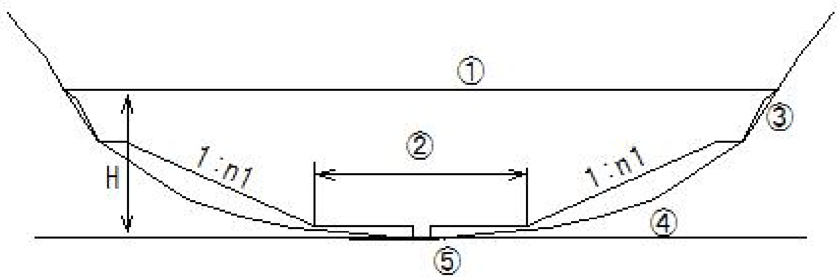


Figure 4.3.3 Example 1 of embankment cut-and-cover cross section when excavation affects the ground

(I1777) Abolition of agricultural reservoirs

(I1777) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

② Cut-and-cover bottom width

③ Top of embankment

▽④ Deepest part of reservoir

⑤ Guide bottom waterway

⑥ Filled fill

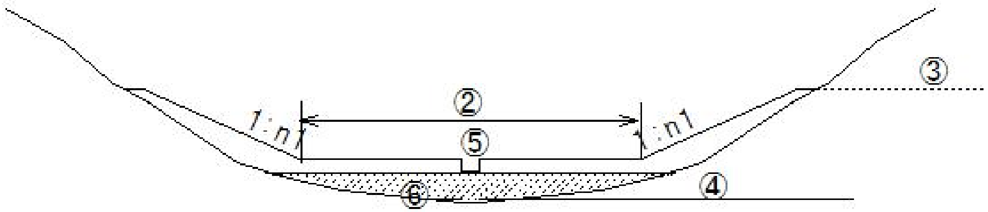


Figure 4.3.4 Example 2 of embankment cut-and-cover cross section when excavation affects the ground

(I1778) Abolition of agricultural reservoirs

(I1778) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

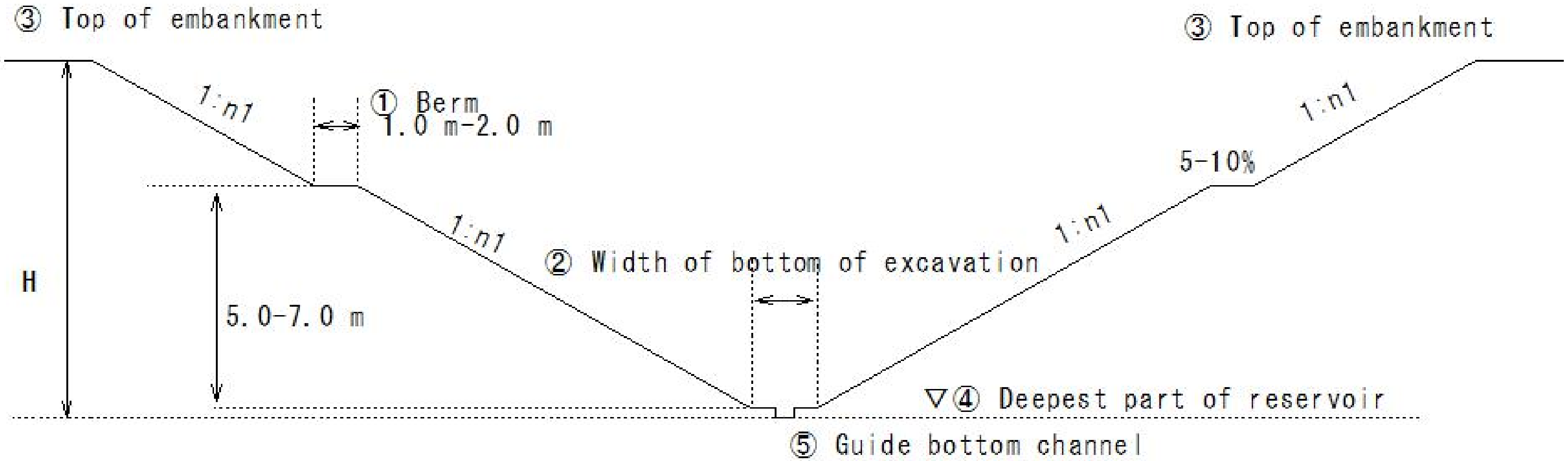


Figure 4.3.5 Example of embankment cut cross section when berm is provided

(I1779) Abolition of agricultural reservoirs

(I1779) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.3.3 Consideration of the guide channel

① Clearance
② Lining
③ Clearance
④ Design flood level
⑤ 10-year return water level
⑥ Control width
⑦ 2-year return water level
⑧ Guide bottom channel
⑨ Control width
⑩ Minimum cross section
30 cm or more
⑪ Lining
⑫ Concrete, etc.
⑬ Vegetation works

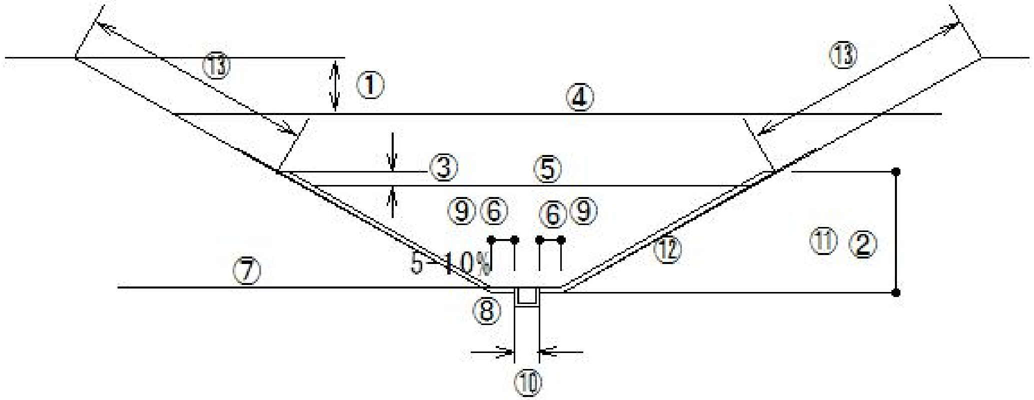


Figure 4.3.6 shows an example of the layout of the guide bottom channel, lining, and slope protection works.

(I1780) Abolition of agricultural reservoirs

(I1780) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.4 Design of downstream connecting channel

In order to safely drain the wastewater from the abandoned reservoir to the drainage channel, a downstream connecting channel should be constructed as necessary.

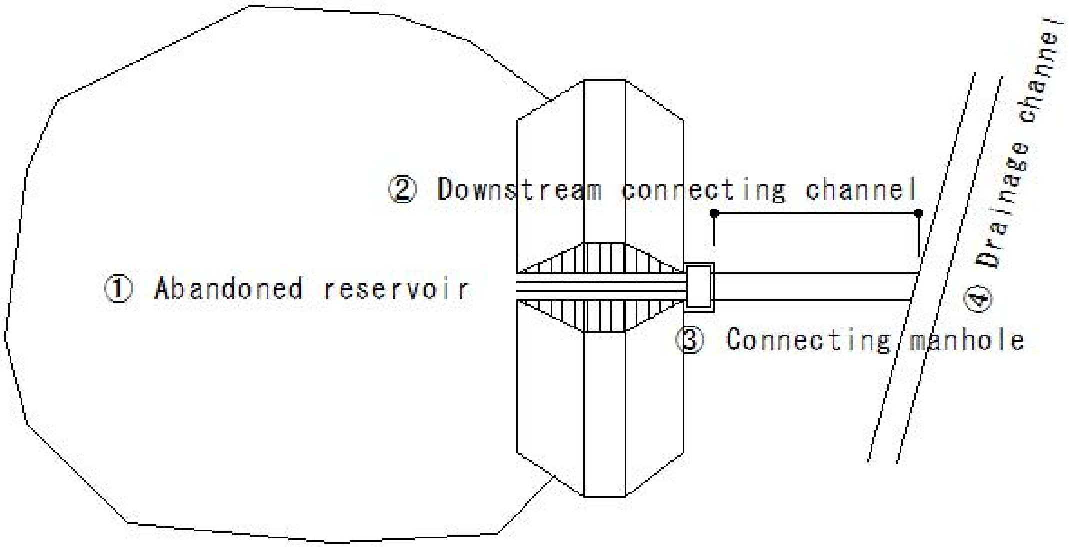


Figure 4.4.1 Drainage channel of abandoned reservoir and downstream connecting channel

(I1781) Abolition of agricultural reservoirs

(I1781) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.5 Design of auxiliary facilities

Considering the prevention of sediment runoff downstream and damage caused by drainage after the reservoir is abolished using the embankment cut-and-cover construction method, and maintenance and management, auxiliary facilities will be installed as necessary.

Inlet

Sediment retention

①Sediment retention

②Gabion basket, etc.

③End protection work

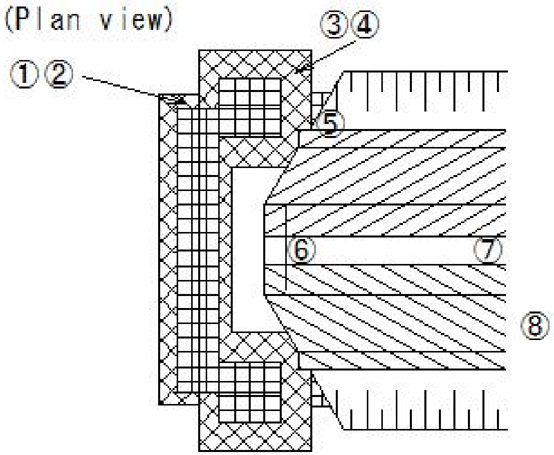
④Vegetation sandbags, etc.

⑥Water cut-off wall

⑦Induction bottom waterway

⑧Lining section

(Plan view)



※⑤Leave a width that does not obstruct the flow of floodwaters, and install the sediment retention

Figure 4.5.1(1) Example of installation of sediment retention using gabion baskets, etc.

(I1782) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.5 Design of auxiliary facilities

① Guiding bottom
② Waterway bottom height
③ Ground improvement
④ As necessary
⑤ Suction prevention material
⑥ Synthetic nonwoven fabric
⑦ Sand retaining wall
⑧ Gabion basket, etc.
⑨ Edge protection work
⑩ Vegetation sandbag, etc.
⑪ Water cut-off wall
⑫ Sand retaining wal
⑬ Gabion basket, etc.
⑭ Design flood level
⑮ 10-year probable water level
⑯ Sand retaining wall fixing work
⑰ Steel bar or wooden pile

(Longitudinal section) (Transverse section)

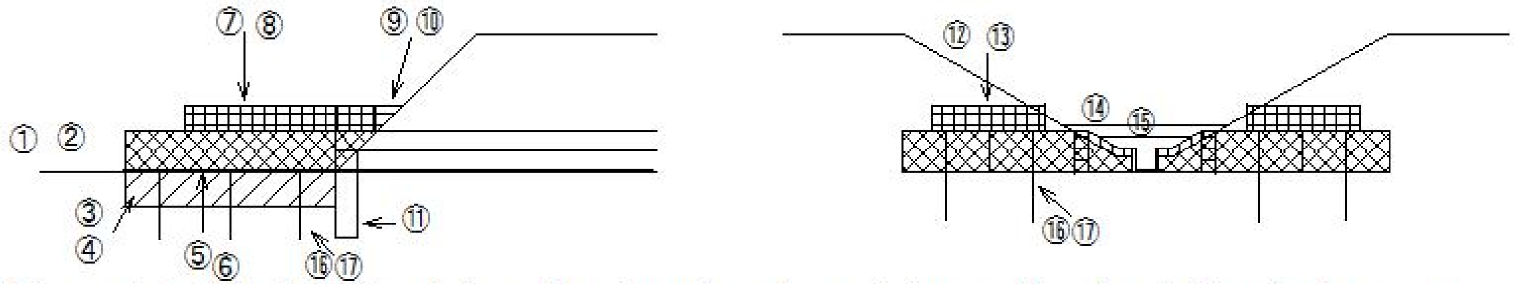


Figure 4.5.1(2) Example of installation of sand retaining wall using Gabion basket, etc.

(I1783) Abolition of agricultural reservoirs

(I1783) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.5 Design of auxiliary facilities

①Catchment basin
②Waterstop
③Height of guiding bottom channel
④Sand pit-20 cm
⑤Ground improvement - if necessary
⑥Waterstop
⑦Lining
⑧Guiding bottom channel
⑨Lining

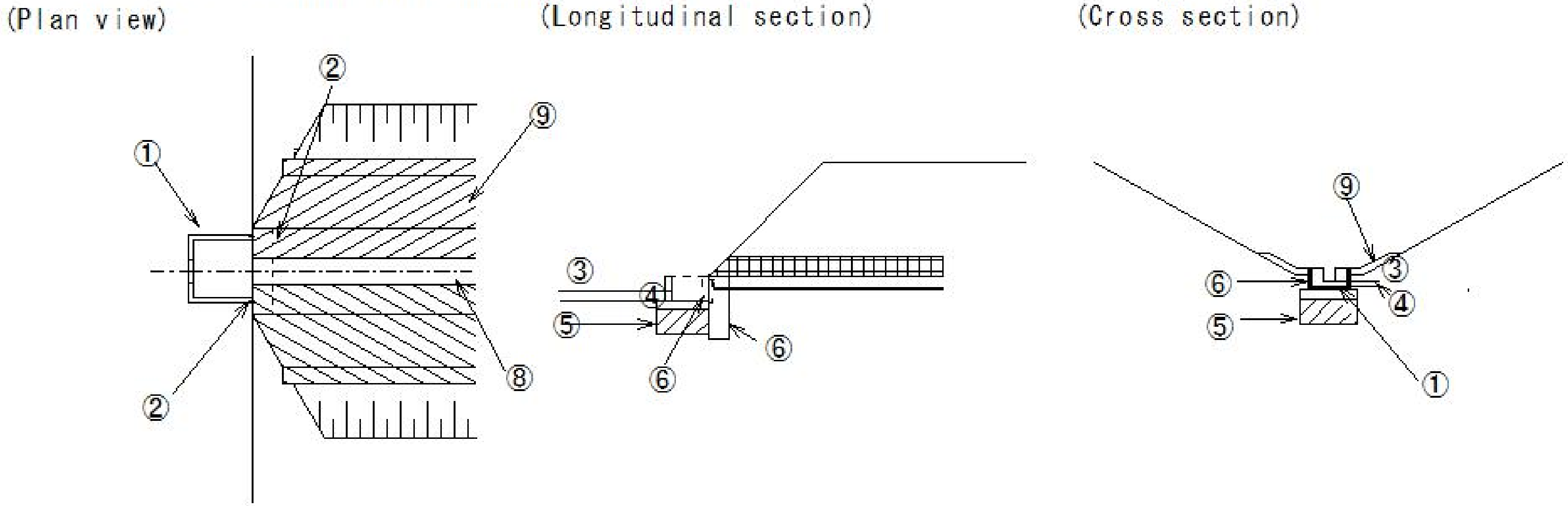


Figure 4.5.2 Example of catchment basin installation

(I1784) Abolition of agricultural reservoirs

(I1784) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

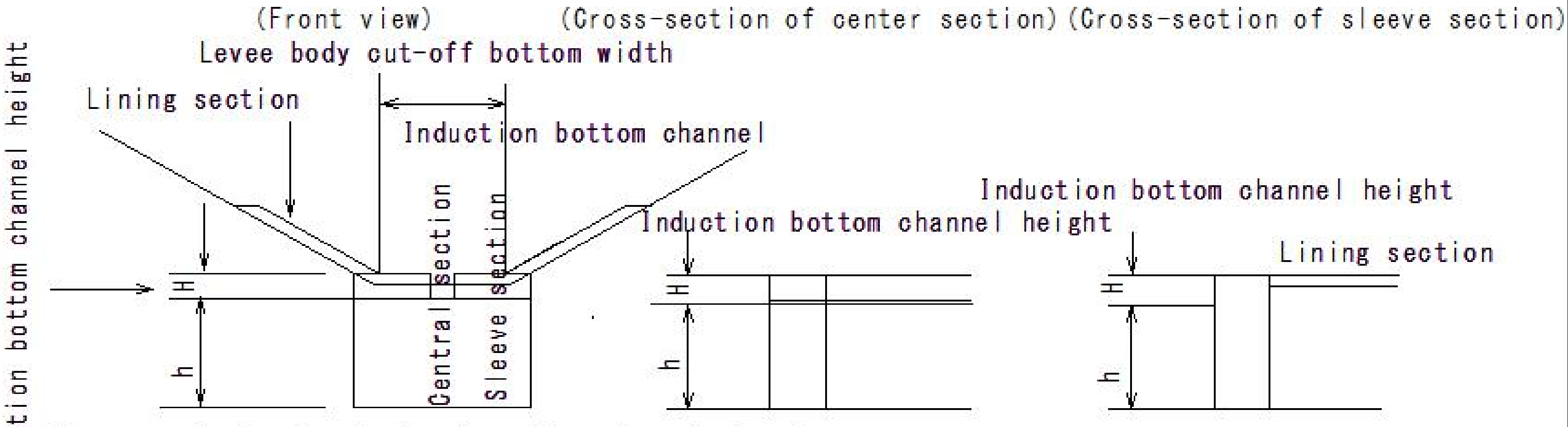
Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.5 Design of auxiliary facilities

○ Water cut-off wall (Figure 4.5.3)

To prevent soil particles from flowing out due to seepage water and ensure the stability of the induction channel, a water cut-off wall is provided at the upstream end of the induction channel.



In case of the foundation is soil and sand, h=1.0 m

In case of the foundation is bedrock, h<1.0 m

Figure 4.5.3 Example of water cut-off wall structure

(I1785) Abolition of agricultural reservoirs

(I1785) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.5 Design of auxiliary facilities

(2) Discharge section

①Induction channel (normal flow)

②(cross section of downstream side of connecting manhole)

③Connecting manhole

④Downstream connecting channel

⑤Width of downstream connecting channel

⑥(cross section of upstream side of connecting manhole)

⑦Width of downstream connecting channel corresponding to the flow rate of downstream connecting channel

Width of downstream connecting channel

⑧Lining section

⑨Induction bottom channel

⑩The size should be easy to maintain and should be determined according to the surrounding topography.

⑪The width should be such that it can be connected to the downstream connecting channel and that it can be connected to the cross section of the induction channel corresponding to the flow rate.

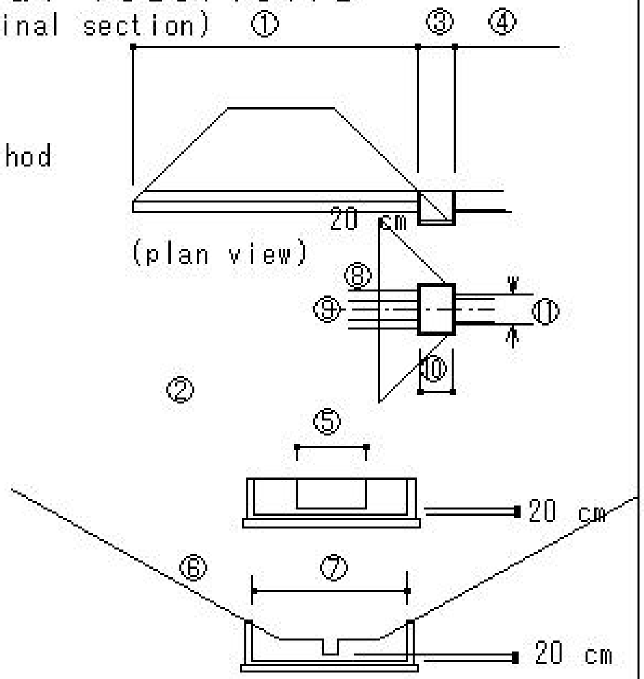


Figure 4.5.4 Example of connecting manhole structure

(I1786) Abolition of agricultural reservoirs

(I1786) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.5 Design of auxiliary facilities

○ Rapid flow construction

① Induction channel
② Rapid flow construction
③ Rapid flow section
④ Downstream connecting channel
⑥ Ensure the necessary height for energy dissipation construction

(Longitudinal section)

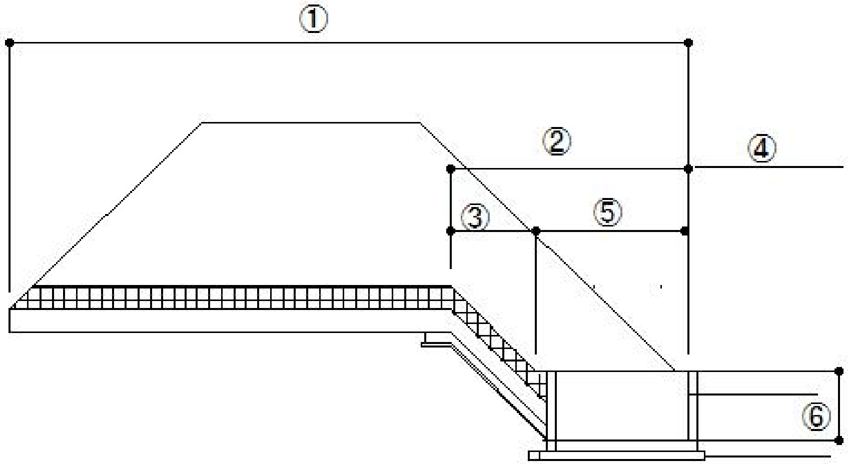


Fig. 4.5.5(1) Example of rapid flow construction structure

(I1787) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs
Reservoir abolition construction methods
Chapter 4 Design of embankment cut-and-cover construction method
4.5 Design of auxiliary facilities

○ Rapid flow construction

① Width of downstream connecting channel

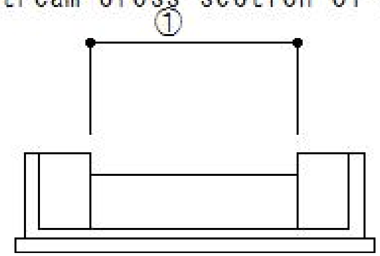
② Lining section

③ Ensure necessary energy dissipation length

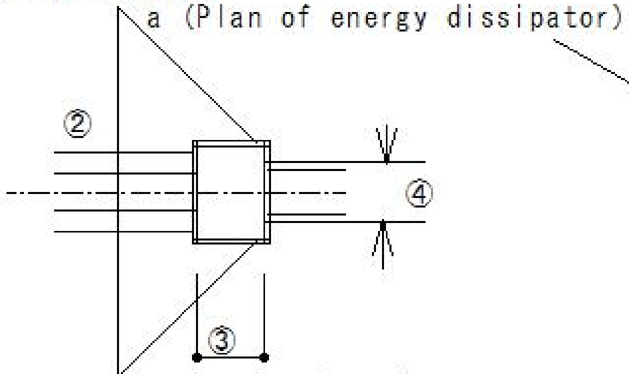
⑤ Width that can ensure necessary energy dissipator side wall height

(Longitudinal section)

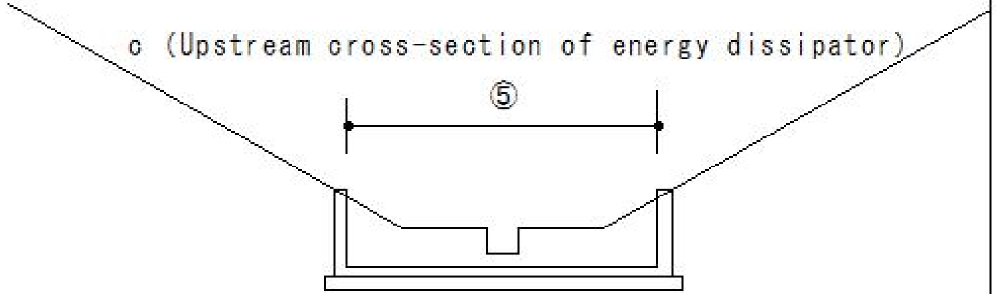
b (Downstream cross-section of energy dissipator)



a (Plan of energy dissipator)



c (Upstream cross-section of energy dissipator)



④ Width that can be connected to downstream connecting channel and also to the downstream cross-section of the induction channel corresponding to the flow rate.

Fig. 4.5.5(2) Example of energy dissipator structure

(I1788) Abolition of agricultural reservoirs

(I1788) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.5 Design of auxiliary facilities

○ Other facilities

① Retaining wall

② Retaining channel

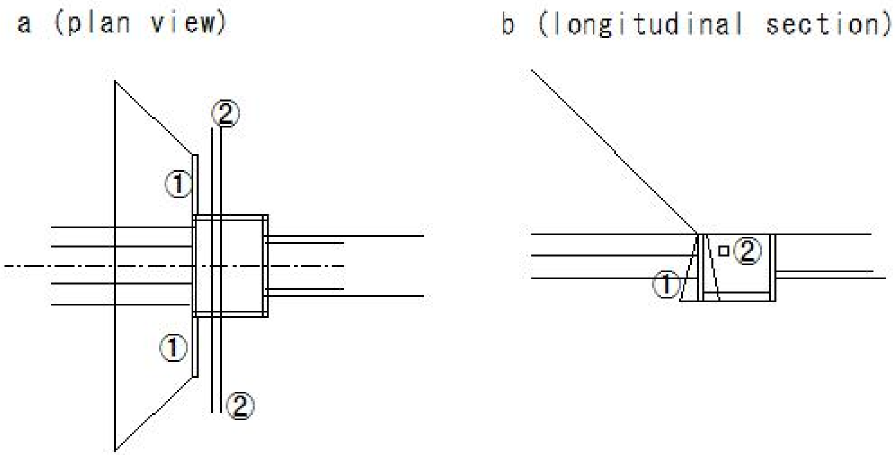


Figure 4.5.6 Example of retaining wall and channel structure

(I1789) Abolition of agricultural reservoirs

(I1789) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment

cut-and-cover construction method

4.5 Design of auxiliary facilities

○ Other facilities

○ Sand pit

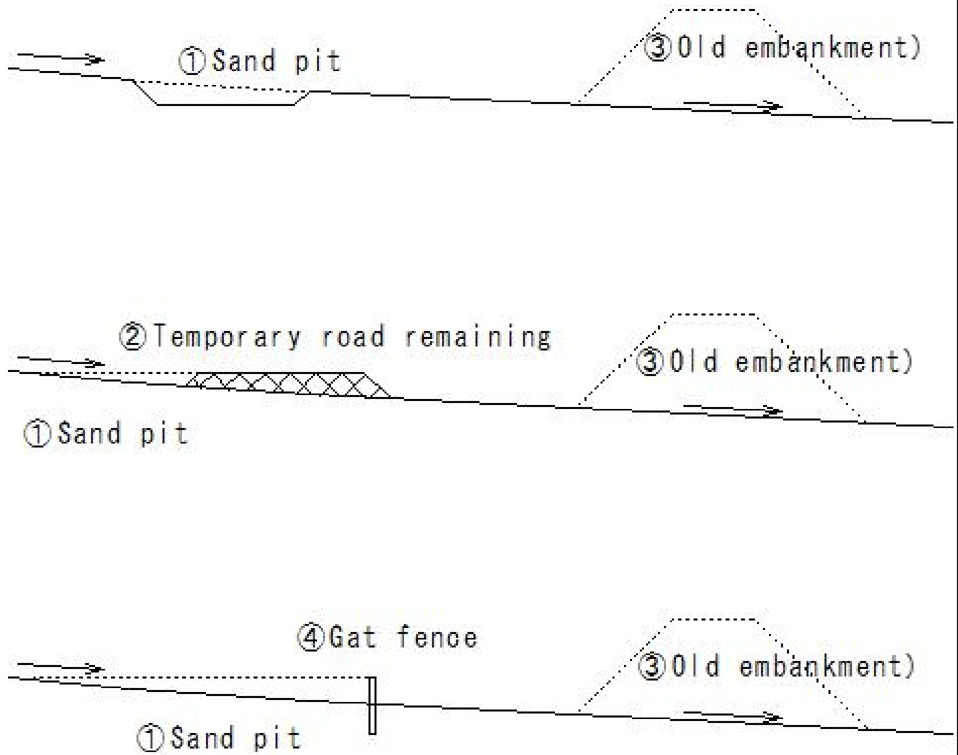


Figure 4.5.7 Example of sand pit

(I1790) Abolition of agricultural reservoirs

(I1790) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

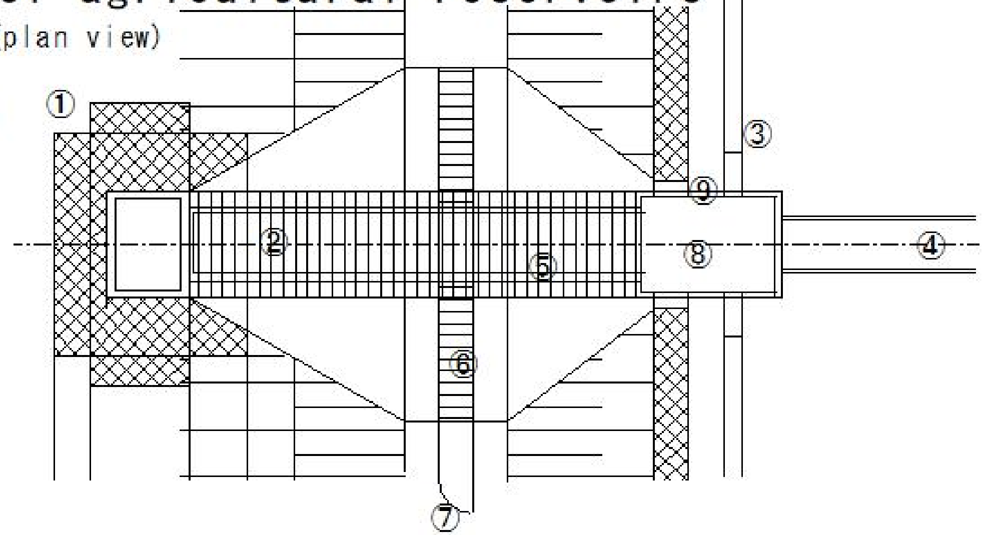
Chapter 4 Design of embankment cut-and-cover construction method

4.7 Examples of standard facilities

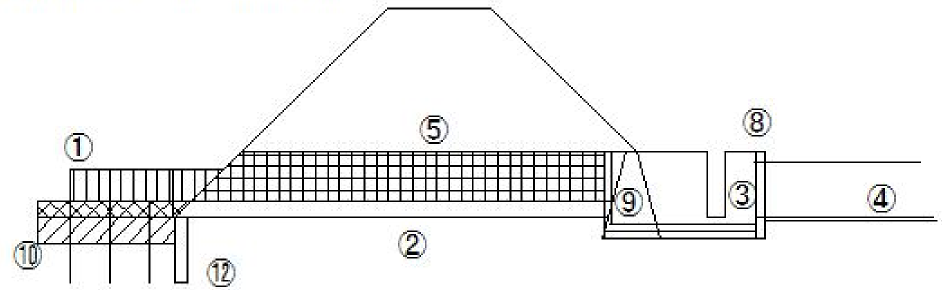
(1) Example of construction plan 1

① Soil retaining wall
② Guide bottom channel
③ Receiving channel
④ Downstream connecting channel
⑤ Lining section
⑥ Staircase work
⑦ Fence, gate
⑧ Connecting sump
⑨ Retaining wall
⑩ Ground improvement
⑪ Guide bottom channel
⑫ Water cut-off wall

(plan view)



(longitudinal section)



(I1791) Abolition of agricultural reservoirs

(I1791) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 4 Design of embankment cut-and-cover construction method

4.7 Examples of standard facilities

(2) Example of construction plan 2

① Water collection basin

② Guide bottom channel

③ Energy dissipation work

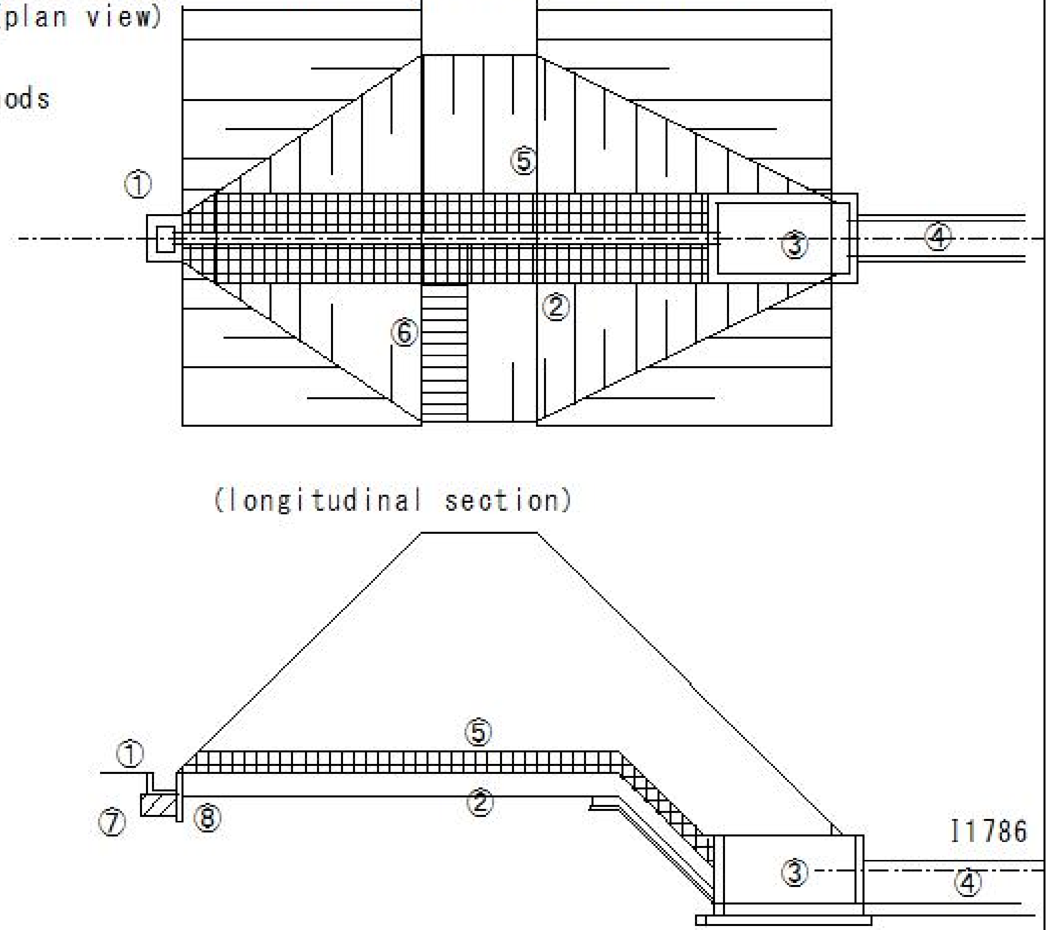
④ Downstream connecting channel

⑤ Lining section

⑥ Step work

⑦ Ground improvement work

⑧ Water cut-off wall



(I1792) Abolition of agricultural reservoirs

(I1792) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 5 Design of culvert construction method

5.1 Structure of culvert construction method and definition of terms

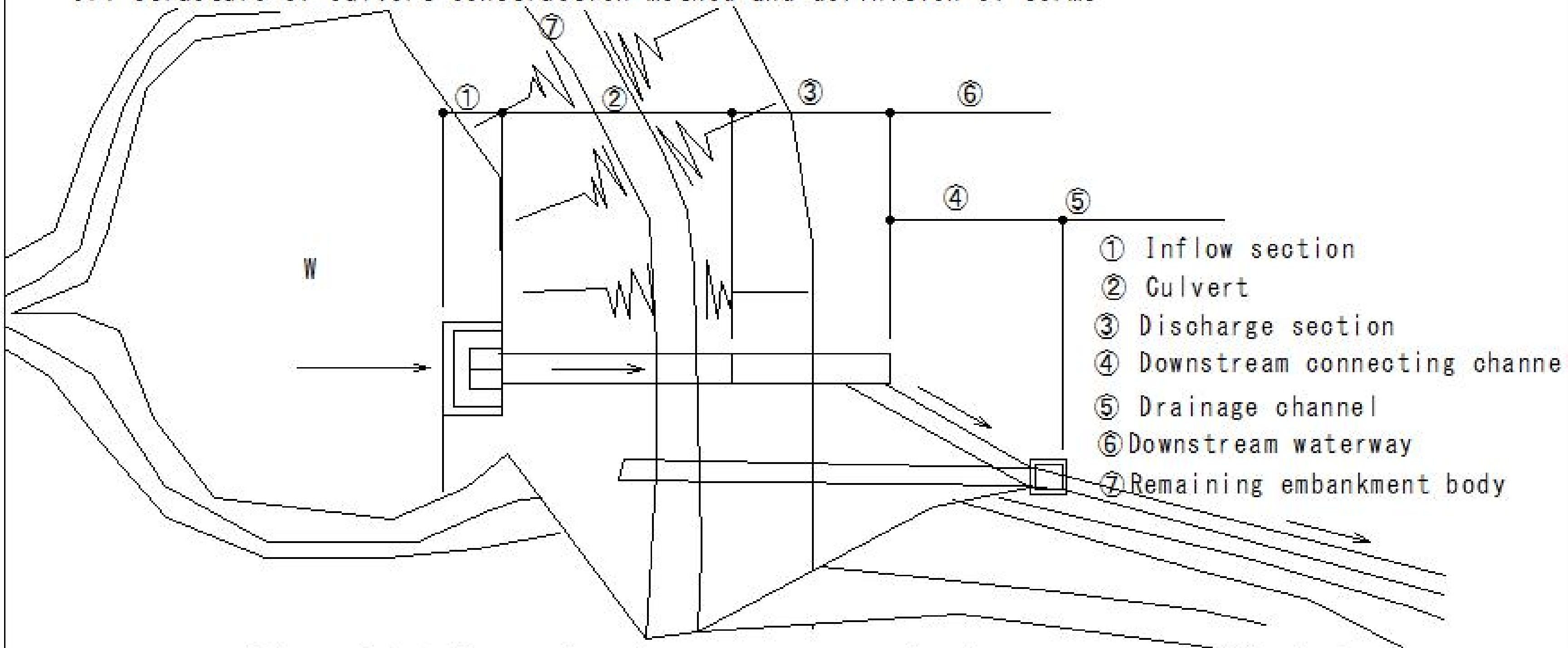


Figure 5.1.1 Names of each component part of culvert construction method

(I1793) Abolition of agricultural reservoirs

(I1793) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction methods

Chapter 5 Design of culvert construction method

5.1 Structure of culvert construction method and definition of terms

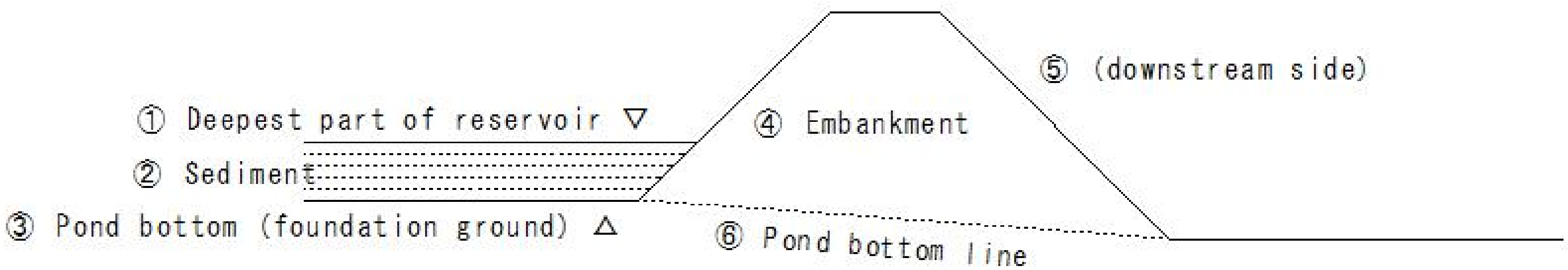


Figure-5.1.2 Deepest part of reservoir

(I1794) Abolition of agricultural reservoirs

(I1794) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 5 Design of culvert construction method

5.3.2 Cross-sectional examination of the underdrain construction method

Ensure a clearance of 1.0 m or more between the design flood level and the underdrain top plate

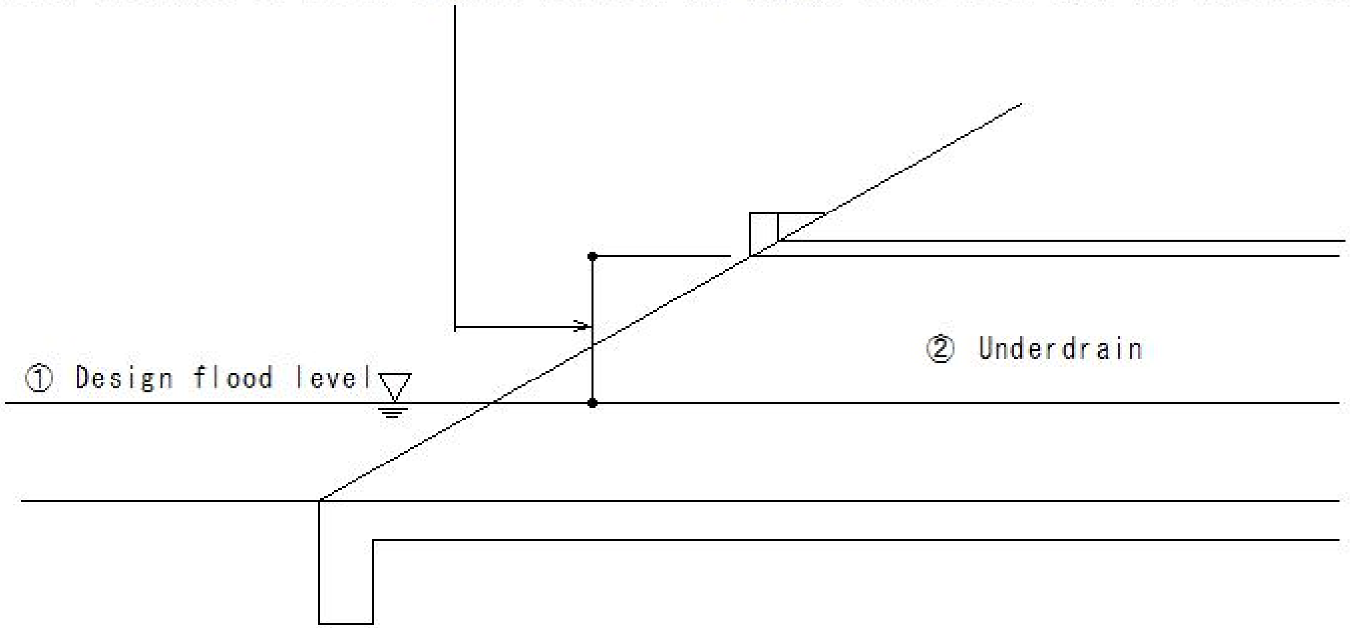


Figure 5.3.1 Clearance of the underdrain

(I1795) Abolition of agricultural reservoirs

(I1795) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 5 Design of culvert construction method

5.3.2 Cross-sectional examination of the underdrain construction method

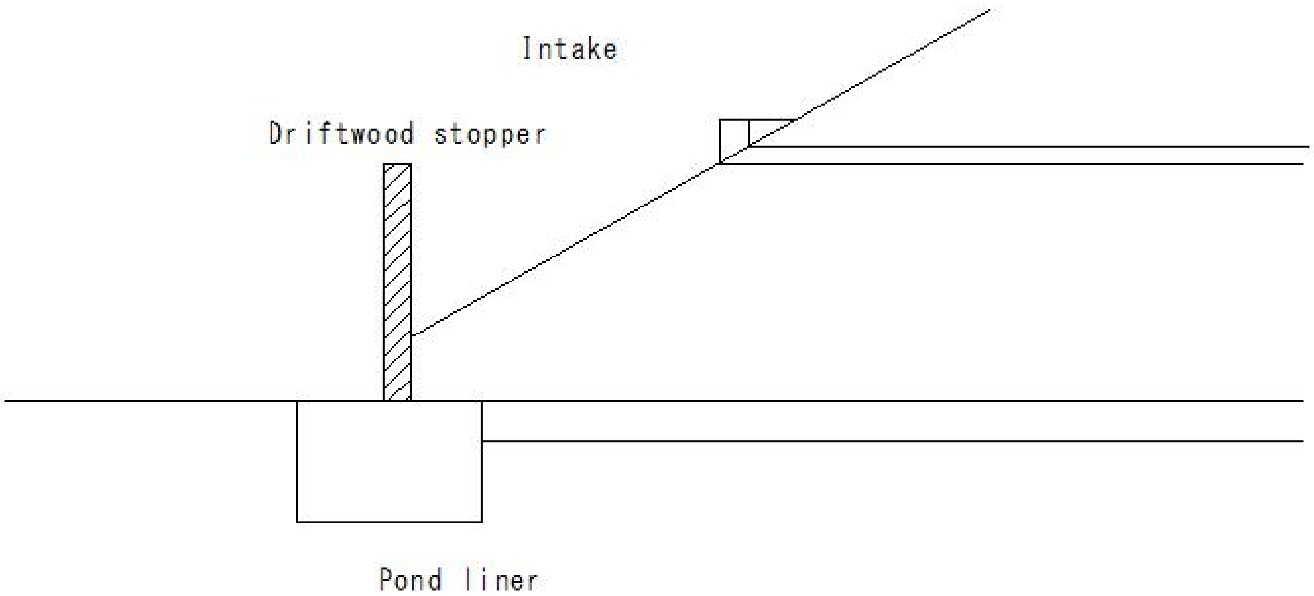


Photo 5.3.1 Example of a driftwood stopper installed on the upstream side of the culvert

(I1796) Abolition of agricultural reservoirs

(I1796) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 6 Design of landfill construction method

6.1 Composition of landfill construction method and definition of terms

① Inflow
② Landfill area
③ Landfill embankment
④ Surface drainage facility
⑤ Downstream connecting channel
⑥ Remaining embankment
⑦ Drainage channel
⑧ Underground drainage facility

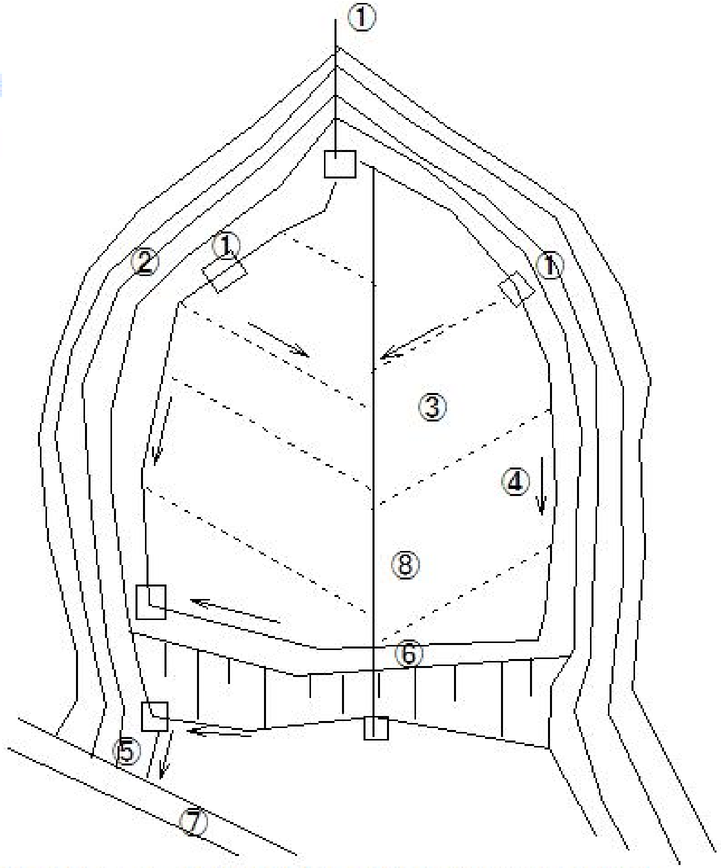


Figure 6.1.1 Names of each component of landfill construction method

(I1797) Abolition of agricultural reservoirs

(I1797) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 6 Design of landfill construction method

○Slope gradient

①Landfill embankment

②Remaining embankment 30 degrees or less

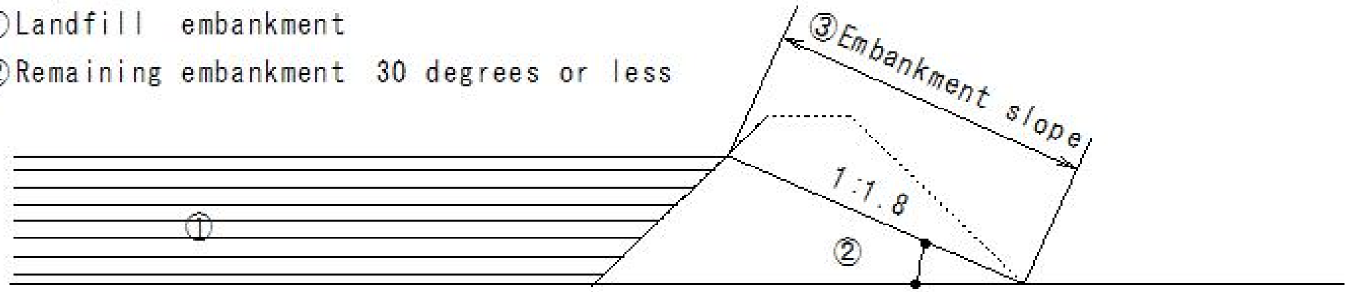


Figure-6.2.1 Slope gradient of embankment slope

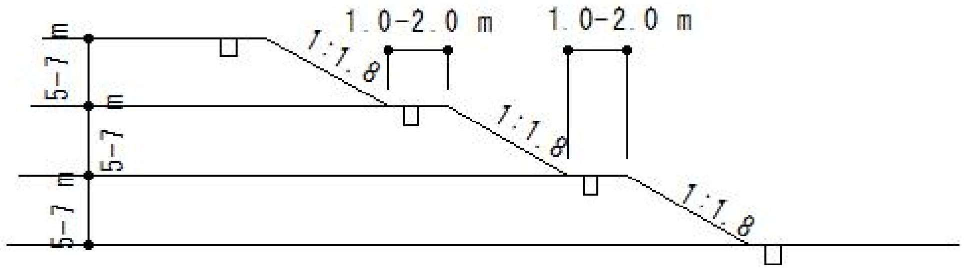


Figure-6.2.2 Example of berm installation on embankment slope

(I1798) Abolition of agricultural reservoirs

(I1798) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 6 Design of landfill construction method

6.3 Drainage facilities

Drainage facilities are planned to safely remove surface water and groundwater from streams, rainwater, spring water, and groundwater.

① Inflow
② Connection sump
③ Surface drainage facility
④ Sediment sump
⑤ Downstream connection channel
⑥ Destination channel

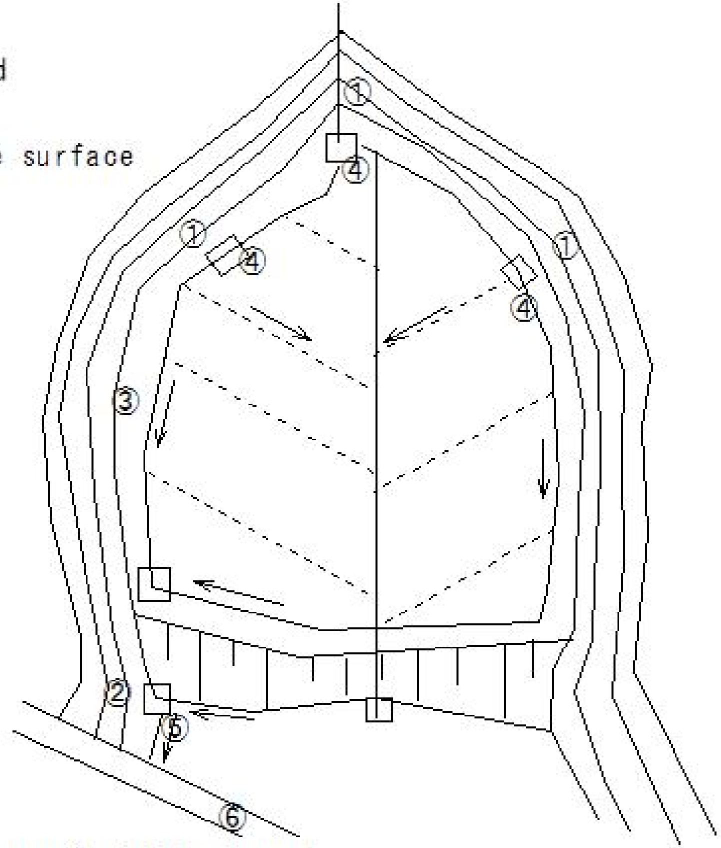


Figure 6.3.1 Example of surface drainage facility layout

(I1799) Abolition of agricultural reservoirs

(I1799) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 6 Design of landfill construction method

6.3 Drainage facilities

(2) Underground drainage facilities

①Landfill area
②Main pipe
③Downstream connecting channel
④Drainage channel
⑤Landfill embankment
⑥Cross-sectional view position
⑦Secondary pipe
⑧Remaining embankment
⑨Flow basin

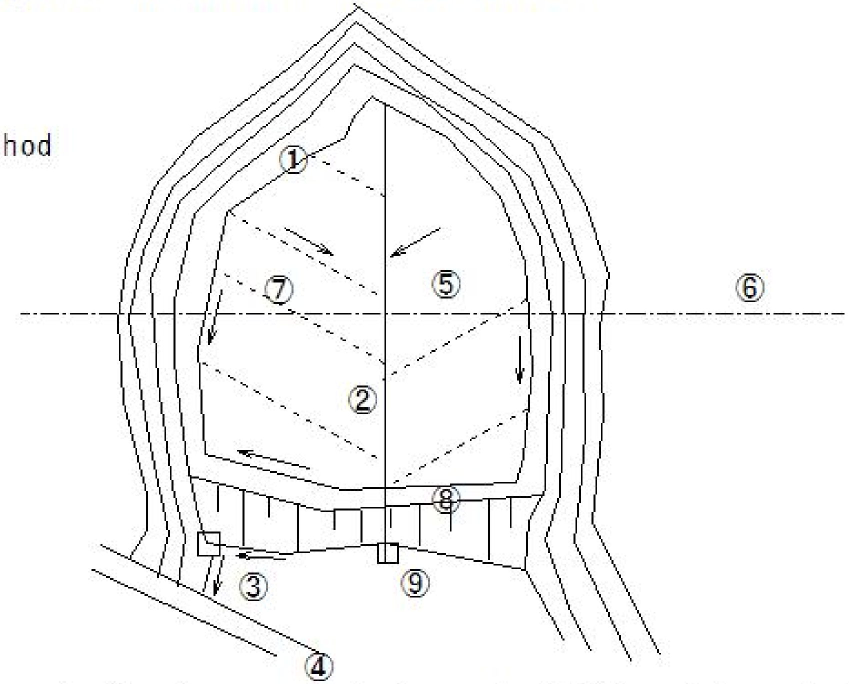


Figure 6.3.2 Example of layout of underground drainage facilities (plan view)

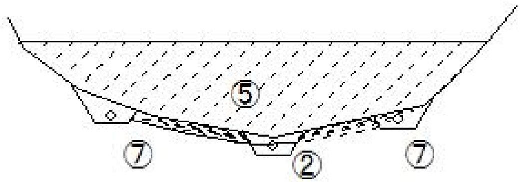


Figure 6.3.3 Example of layout of underground drainage facilities (cross-sectional view)

(I1800) Abolition of agricultural reservoirs

(I1800) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 6 Design of landfill construction method

6.3 Drainage facilities

(2) Underground drainage facilities

① Collection pipe

② (Main pipe φ300 mm or more,

③ Auxiliary pipe φ200 mm or more perforated pipe)

④ Drain material

⑤ (Highly permeable material

⑥ Suction prevention material

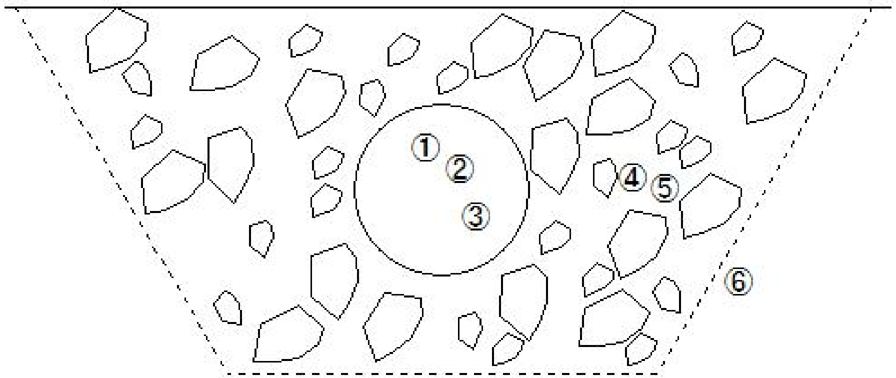


Figure-6.3.4 Example of cross section of collection pipe

(I1801) Abolition of agricultural reservoirs

(I1801) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs
Reservoir abolition construction method
Chapter 6 Design of landfill construction method
6.3 Drainage facilities
(2) Underground drainage facilities
① Collection pipe
② Underground drainage facility drainage basin
③ Sediment pit 20 cm

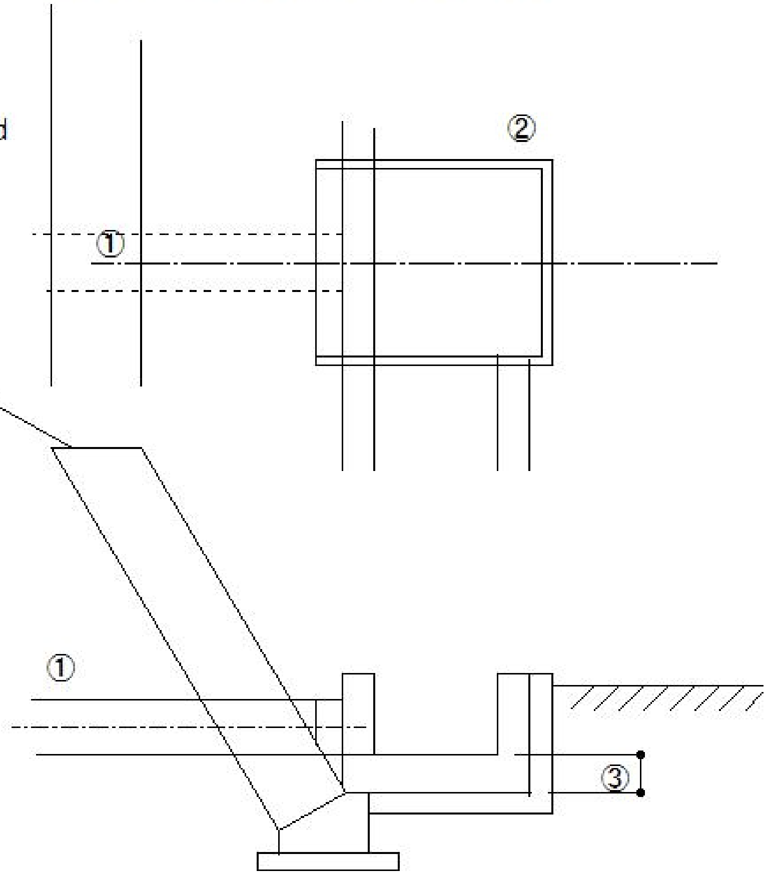


Figure-6.3.5 Example of inlet pit installation

(I1802) Abolition of agricultural reservoirs

(I1802) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 6 Design of landfill construction method

Chapter 7 Construction plan

(1) Construction flow

○ Embankment excavation method, culvert method

① Preparation work

② (Construction preparation, water drainage and drainage treatment)

③ Temporary work

④ (Temporary road)

⑤ Embankment excavation

⑥ Guide channel construction or culvert construction

(1) Construction flow

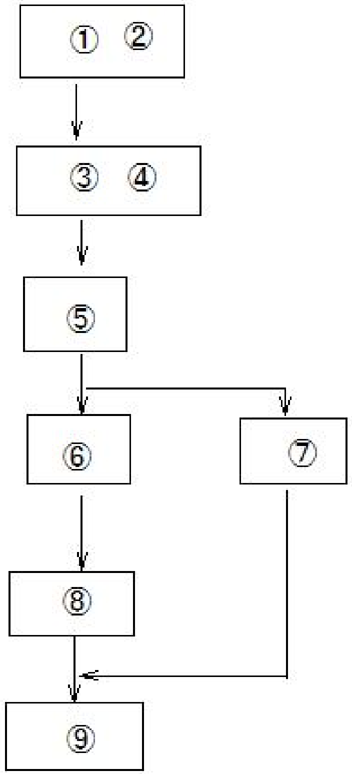


Figure 7.1 Construction flow for embankment excavation method and culvert construction method

(I1803) Abolition of agricultural reservoirs

(I1803) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 6 Design of landfill construction method

Chapter 7 Construction plan

○ Landfill method

① Preparation work

② (Construction preparation, drainage and drainage treatment)

③ Temporary work

④ (Temporary road)

⑤ Landfill embankment

⑥ (Including underground drainage facilities)

⑦ Surface drainage facility work

⑧ Downstream waterway work

⑨ Cleanup

(1) Construction flow

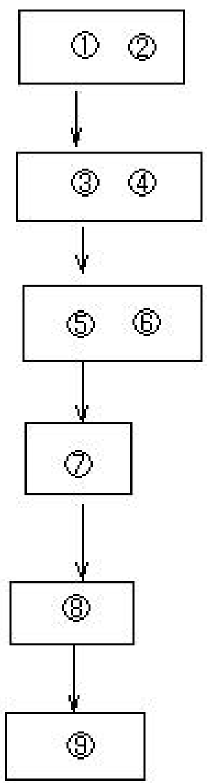


Figure-7.2 Construction flow of the Landfill method

(I1804) Abolition of agricultural reservoirs

(I1804) Abolition of agricultural reservoirs

Abolition of agricultural reservoirs

Reservoir abolition construction method

Chapter 6 Design of landfill construction method

Chapter 7 Construction plan

3) Environmental considerations

- Leave some water areas as biotopes.
- Move and transplant organisms
- Prevent invasion and escape of invasive species
- Measures against turbid water, noise and vibration
- Considerations for temporary construction

①About 50 cm
②▽N.W.L (always)
③Wire cylinder masonry work(gabion)
④ (Embankment)
⑤Water storage for environmental considerations
⑥ (Plants, fish, etc.)
⑦Current ground
⑧ (Deepest part of reservoir)
⑨Reservoir embankment
⑩Induction channel

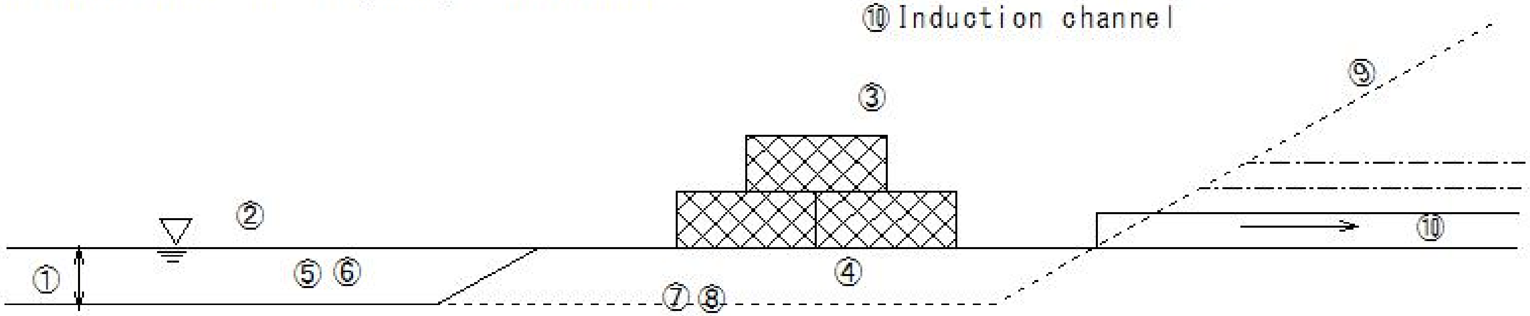


Figure-7.3 An example of environmental considerations that leave some water areas as habitats for organisms

(I1805) Abolition of agricultural reservoirs

(I1805)Reservoirs

1 Roles of reservoirs

○Agricultural role

①Steady supply of water to rice paddies

②Storing water

○Public role

③Fire prevention water source for villages

○Disaster prevention

④Flood control function

○Ecosystem conservation

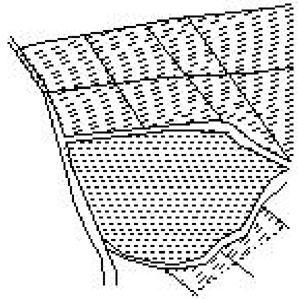
⑤Reservoirs have good conditions as a natural environment

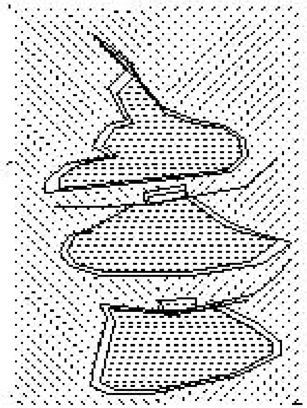
⑥Various creatures live here.

⑦Exterminining invasive fish

○Preserving the landscape and providing health and rest

⑧Places for recreation and rest





I1381

(I1806) Abolition of agricultural reservoirs

(I1806)Reservoirs

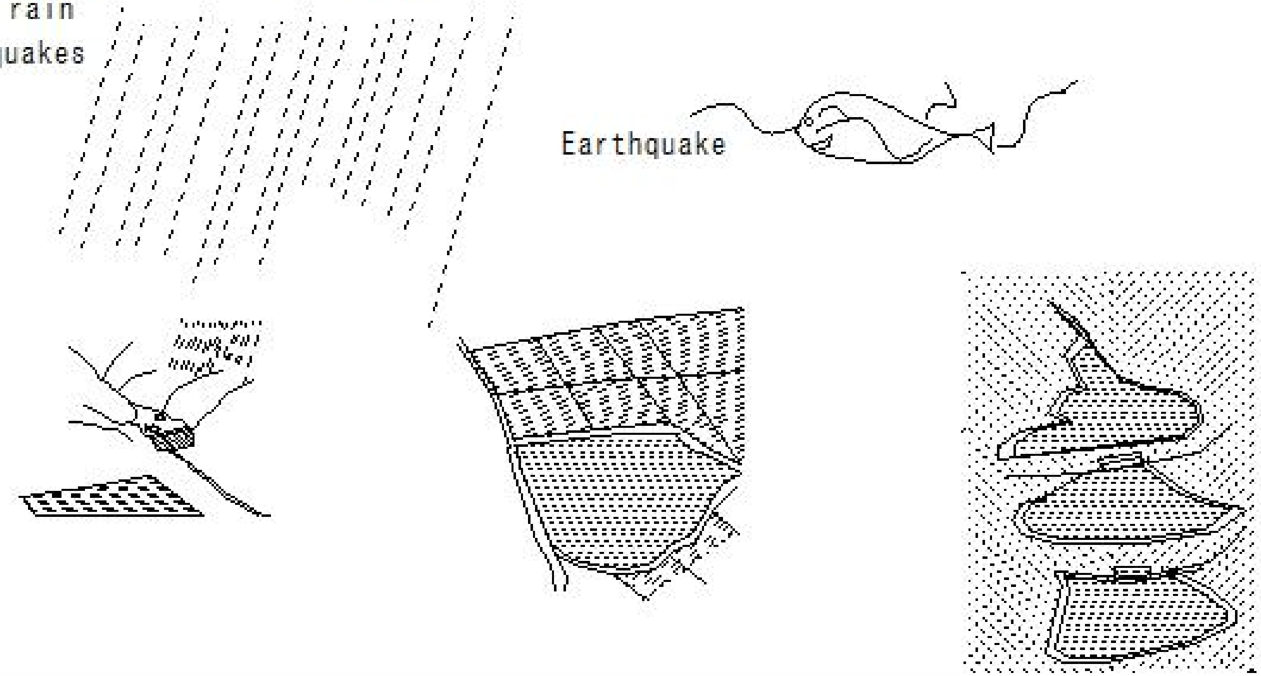
2. The need for proper management

Proper management, such as inspections and repairs according to the condition of the reservoir, should be carried out.

(1) How do reservoirs collapse?

The main direct causes of reservoir collapse are

1. Heavy rain
2. Earthquakes



I1381

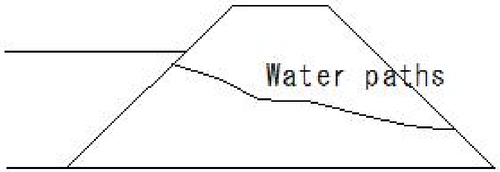
(I1807) Abolition of agricultural reservoirs

(I1807)Reservoirs

Reservoirs

(1) How do reservoirs collapse?

① During heavy rain

Breakdown patterns	Phenomena occurring in the levee body
a Seepage failure 	a Seepage failure: As the levee body becomes damaged, water pressure increases with each rise in the water level, creating water paths* that lead to breaches. The upper part, where water normally does not rise, is often filled with rat holes, which become water paths when the water level rises during heavy rain. * Water paths: A path through which water flows within the levee body, causing leaks.

(I1808) Abolition of agricultural reservoirs

(I1808) Reservoirs

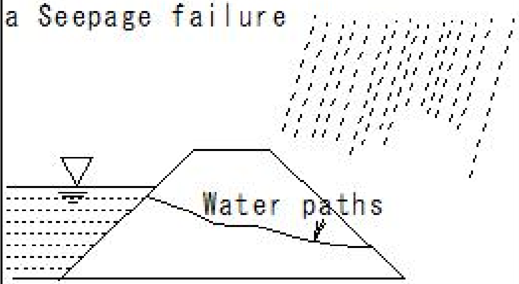
Reservoirs

(1) How do reservoirs collapse?

① During heavy rain

Breakdown patterns / **Phenomena occurring in the levee body**

a Seepage failure

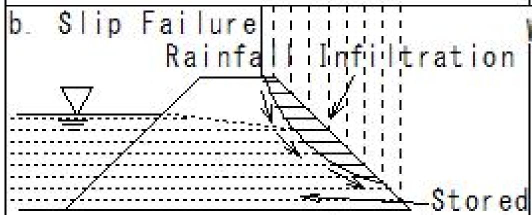


Seepage failure: As the levee body becomes damaged, water pressure increases with each rise in the water level, creating water paths* that lead to breaches.

The upper part, where water normally does not rise, is often filled with rat holes, which become water paths when the water level rises during heavy rain.

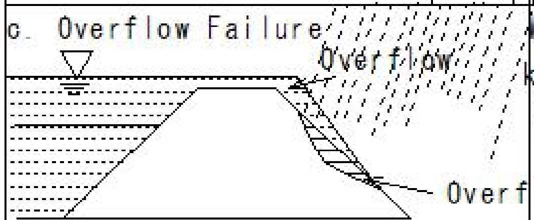
* Water paths: A path through which water flows within the levee body, causing leaks.

b. Slip Failure



Water seeps into the entire levee, weakening its internal strength and causing the slope to slide.

c. Overflow Failure



When heavy rainfall increases the inflow volume and drainage cannot keep up, the water overflows the levee. This causes erosion of the levee, leading to its collapse.

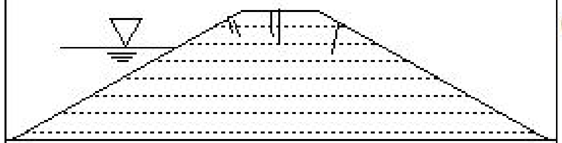
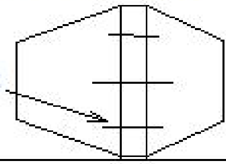
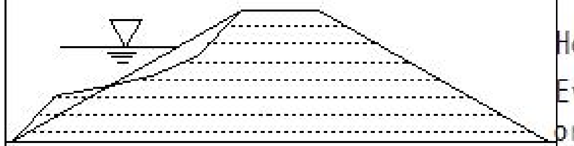
(I1809) Abolition of agricultural reservoirs

(I1809)Reservoirs

Reservoirs

(1) How do reservoirs collapse?

② During an earthquake

Post-earthquake conditions	Level of embankment damage
①Cracks 	Cracks that occur in the embankment can become water channels. Cracks that occur upstream or downstream of the embankment require particular attention. Vertical cracks 
② Subsidence (Settlement) 	This occurs in soft ground. If the embankment maintains its shape, it is considered serious damage.
③ Slope Collapse: 	There are no abnormalities inside the levee, and it will not collapse immediately. However, if the collapse affects the entire levee, caution is required. Even if the collapse is partial, it may spread throughout the levee or cause internal deformation, so caution is advised.

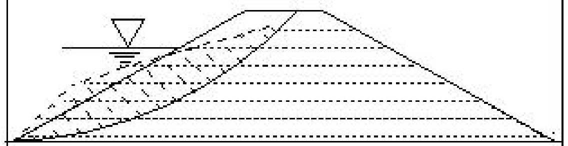
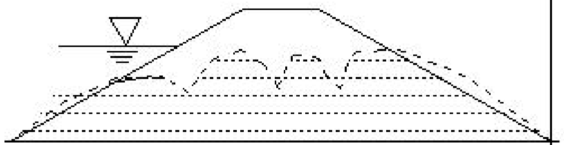
(I1810) Abolition of agricultural reservoirs

(I1810)Reservoirs

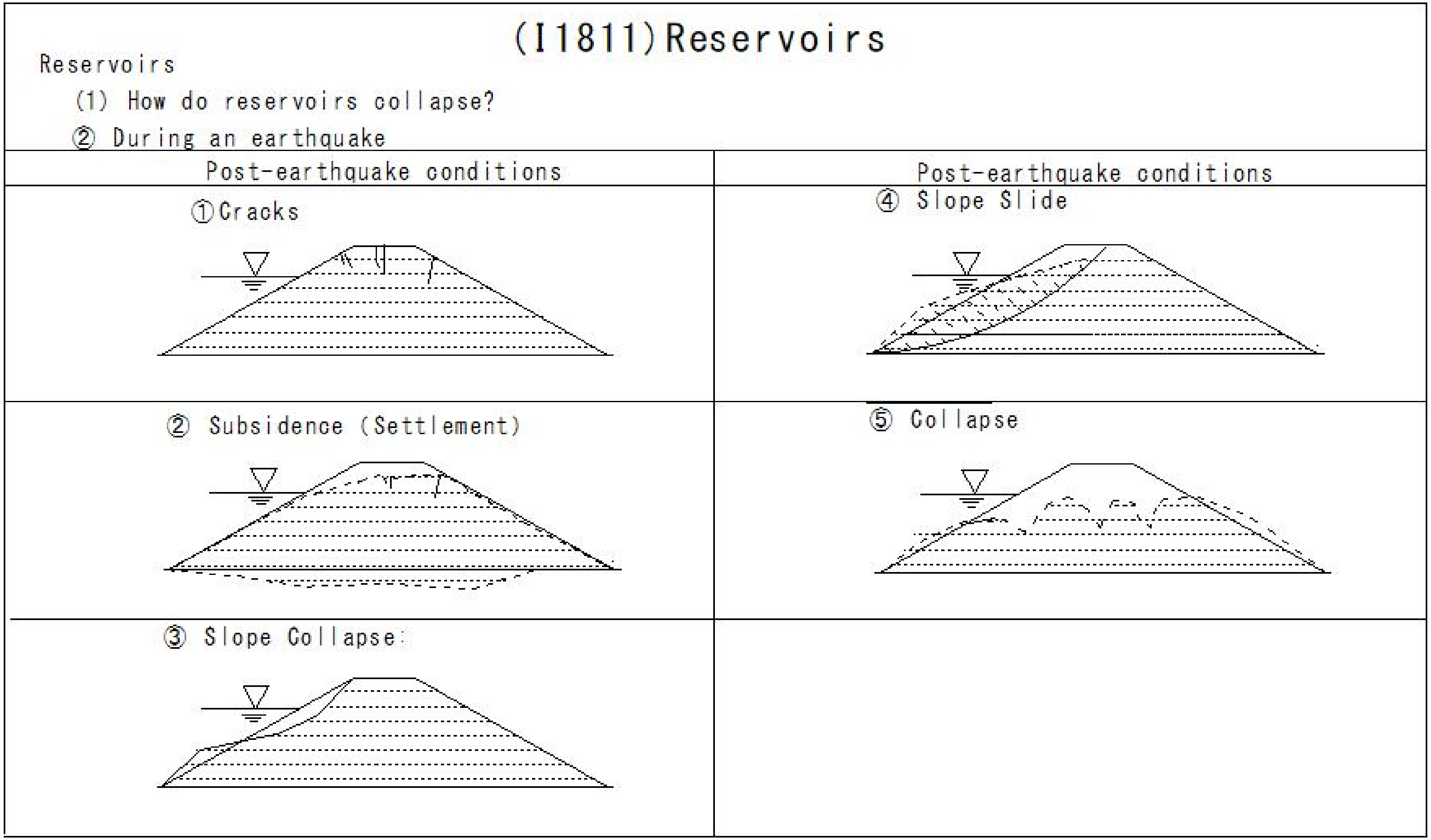
Reservoirs

(1) How do reservoirs collapse?

② During an earthquake

Post-earthquake conditions	Level of embankment damage
④ Slope Slide 	In case of the damage to the slope is significant, a large-scale slide will occur. Cracks may appear as a precursor to a slide.
⑤ Collapse 	This is a dangerous situation in which the damage to the levee body is a high possibility of collapse.

(I1811) Abolition of agricultural reservoirs



(I1812) Abolition of agricultural reservoirs

(I1812) Reservoirs

(2) Damage downstream due to reservoir collapse

① A reservoir collapse will result in the loss of its water storage function.

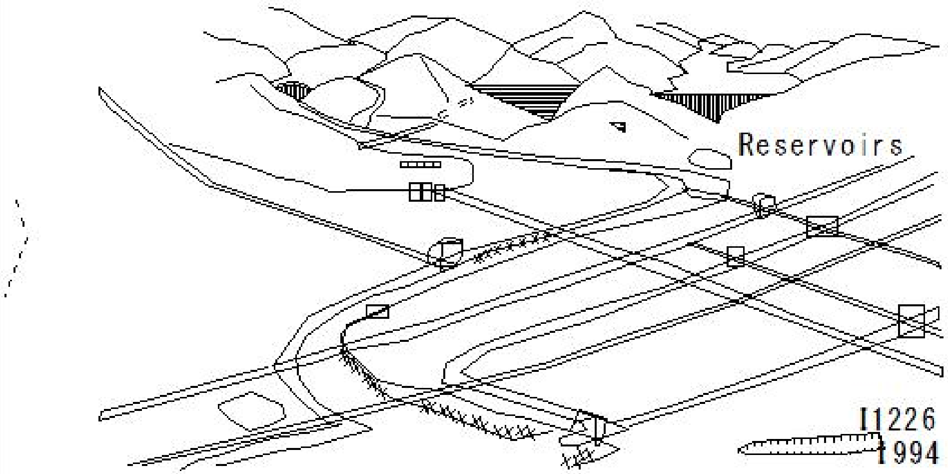
② It will cause serious damage downstream.

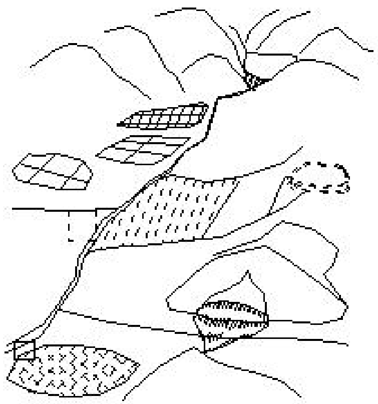
③ The reservoir manager and downstream residents should discuss the matter

④ confirm safe evacuation methods and how to communicate the situation.

⑤ It is effective to create a "hazard map" together.

Hazard map





(I1813) Abolition of agricultural reservoirs

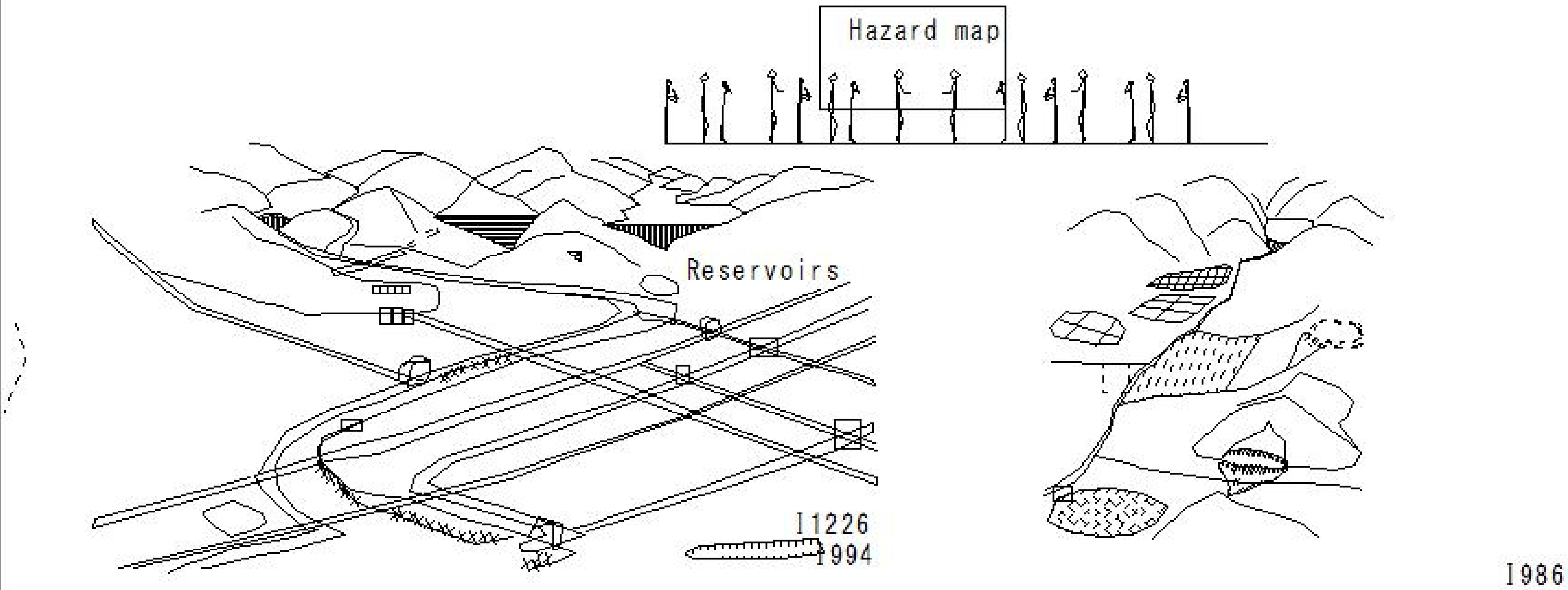
(I1813) Reservoirs

(4) Role of Municipalities in Managing Reservoirs

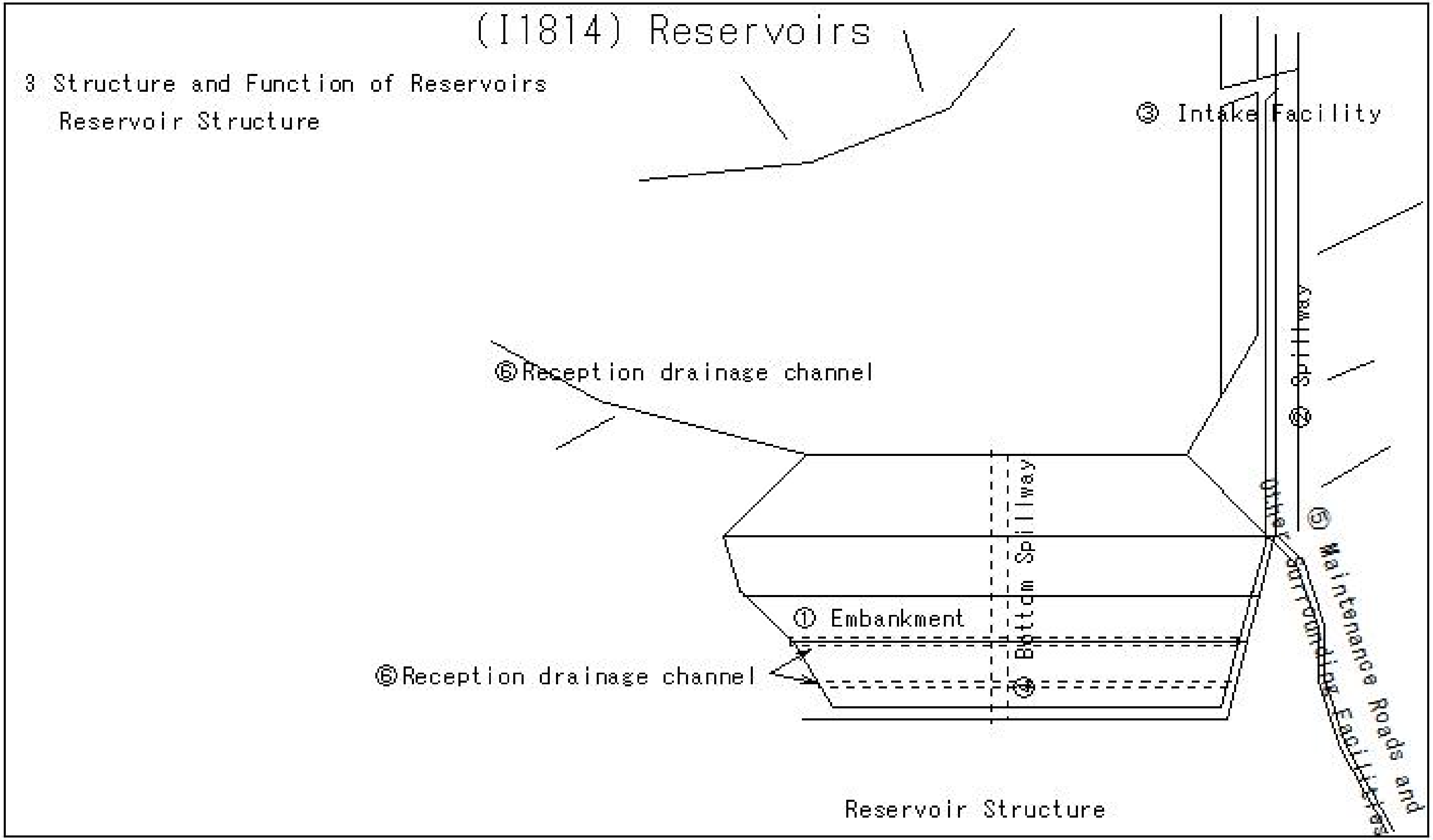
2. The Need for Appropriate Management

(1) Municipalities must be aware of the status of reservoirs from the perspective of regional disaster prevention.

(2) must be able to contact managers and people living downstream in the event of an emergency.



(I1814) Abolition of agricultural reservoirs



(I1815) Abolition of agricultural reservoirs

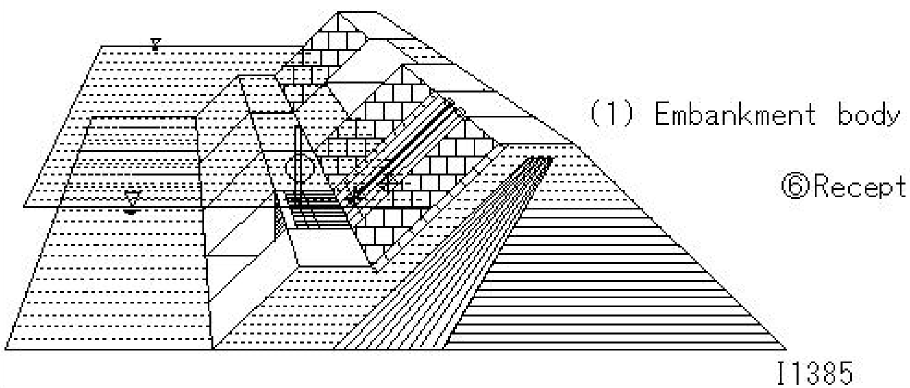
(I1815) Reservoirs

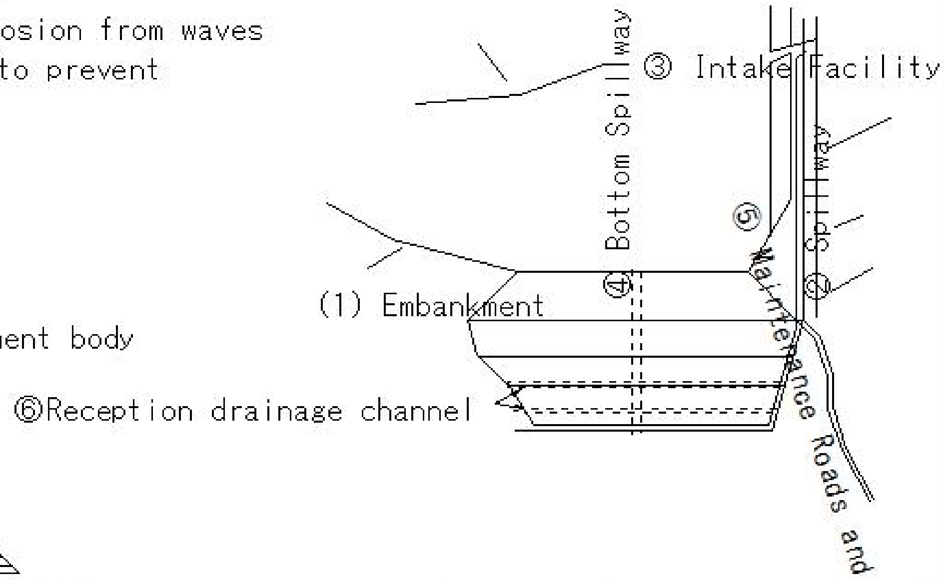
3 Structure and Function of Reservoirs

Reservoir Structure

(1) Embankment body

① Fill to hold back water
② Water-resistant soil is used
③ Clay impermeable soil is placed in the center of the dam body or on the reservoir side
④ Blocks or sheets are laid to prevent erosion from waves
⑤ Reinforcement revetments are installed to prevent slope collapse due to seepage water





Reservoir Structure

(I1816) Abolition of agricultural reservoirs

(I1816) Reservoirs

3 Structure and Function of Reservoirs

Reservoir Structure

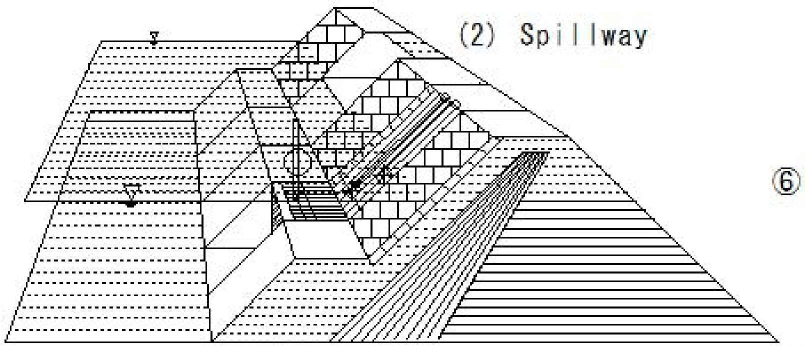
(2) Spillway

① In case of water overflows the levee (overflow), it may cause a breach.

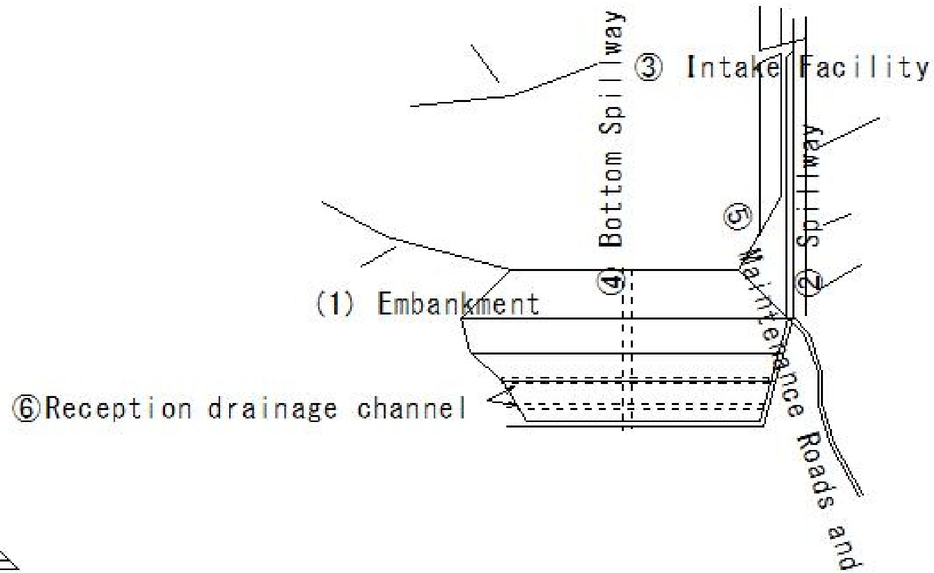
② Prevents the water level from rising above a certain level even during heavy rain.

③ Creates an overflow area in advance.

④ Usually constructed of concrete.



I1385



Reservoir Structure

I1815

(I1817) Abolition of agricultural reservoirs

(I1817) Reservoirs

3 Structure and Function of Reservoirs

Reservoir Structure

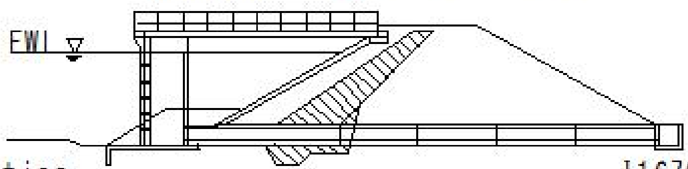
(3) Water Intake Facilities

① A facility for drawing water for agricultural use.

② A gutter that regulates the amount of water by opening and closing the covers of several holes in the slope.

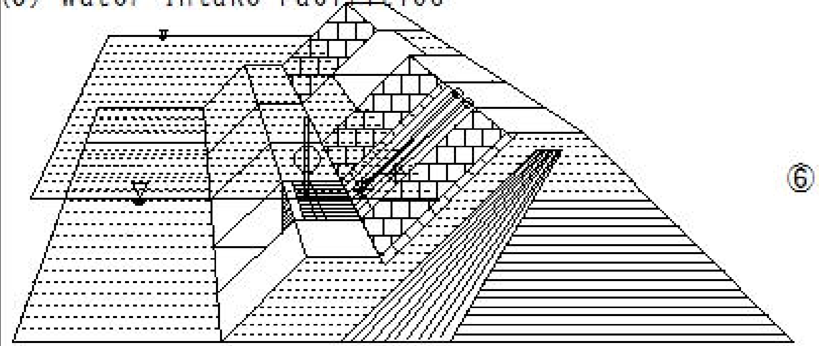
③ Vertical gutter structures that also serve as spillways are becoming more common.

(3) Water Intake Facilities



I1679

(3) Water Intake Facilities



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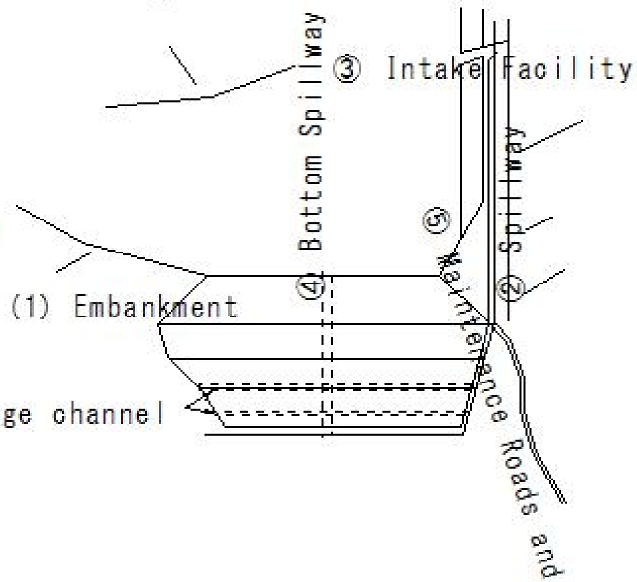


Reservoir Structure I1815

(I1818) Abolition of agricultural reservoirs

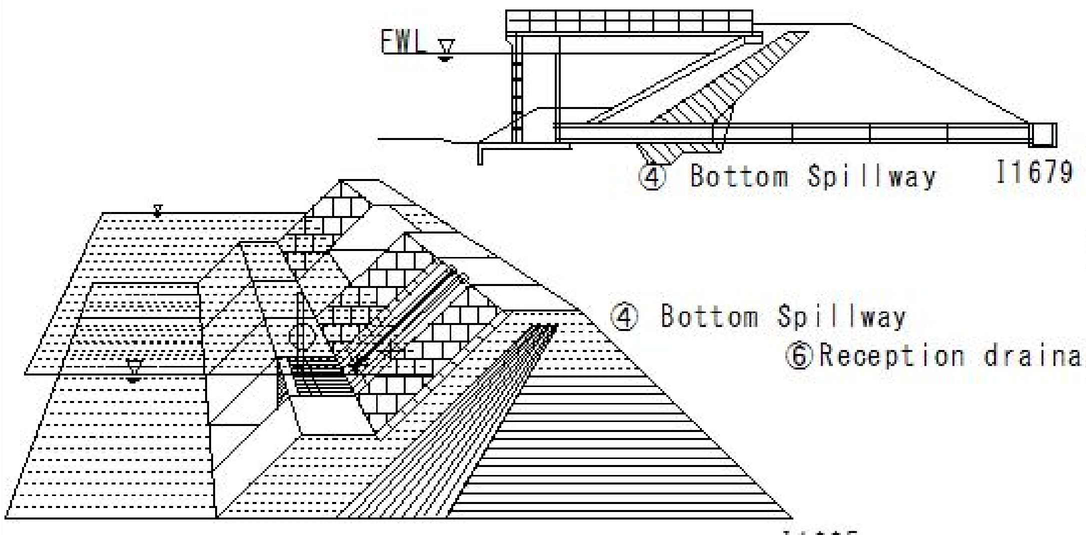
(I1818) Reservoirs

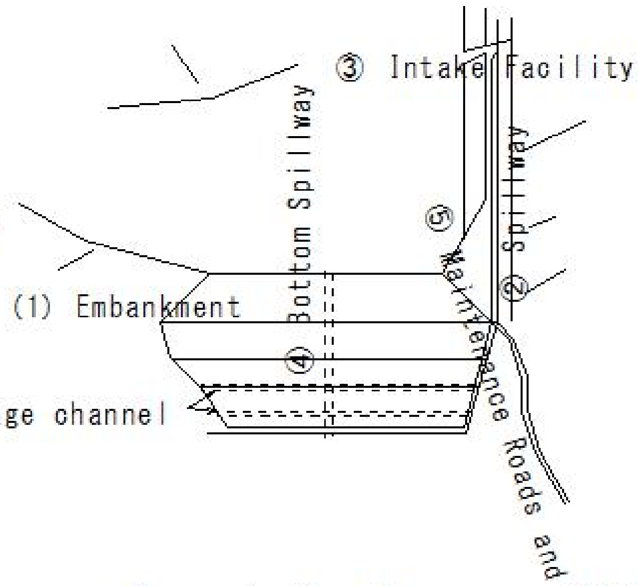
3 Structure and Function of Reservoirs

Reservoir Structure

(4) Bottom drain

① Located at the lowest point to empty the reservoir.





Reservoir Structure

I1815

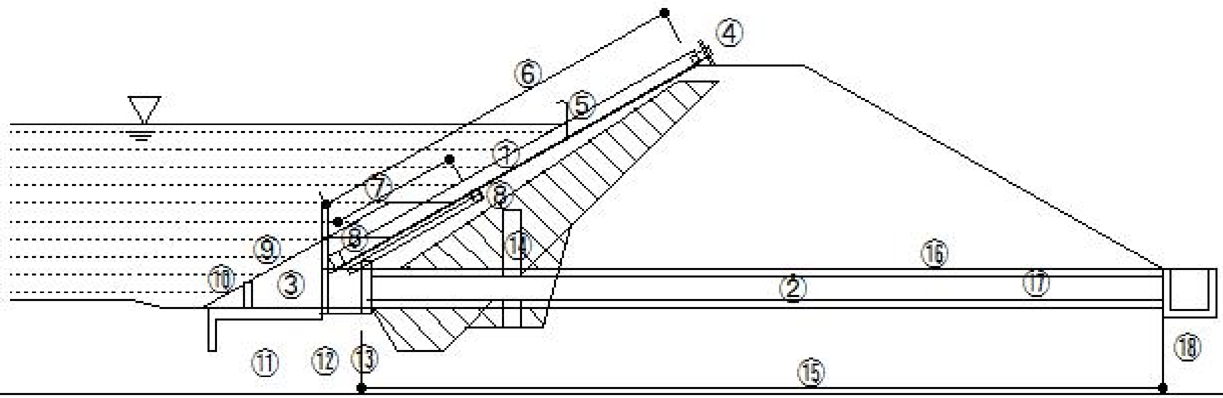
(I1819) Abolition of agricultural reservoirs

(I1819) Reservoirs

3 Structure and Function of Reservoirs

Water intake facility

① Inclined gutter
② Bottom gutter
③ Sediment discharge
④ Winding handle
⑤ Air hole
⑥ Inclined gutter work
⑦ Inclined gutter pipe section
⑧ Water intake hole section (slide gate)
⑨ Sediment discharge gate
⑩ Corner stop
⑪ Attached waterway section
⑫ Sediment discharge section
⑬ Attached box section
⑭ Water cut-off wall
⑮ Low gutter pipe wrapping section
⑯ Low gutter pipe wrapping
⑰ Low gutter pipe
⑱ Outlet manhole work



I1392

(I1820) Abolition of agricultural reservoirs

(I1820) Reservoirs

3 Structure and Function of Reservoirs

Water intake facility

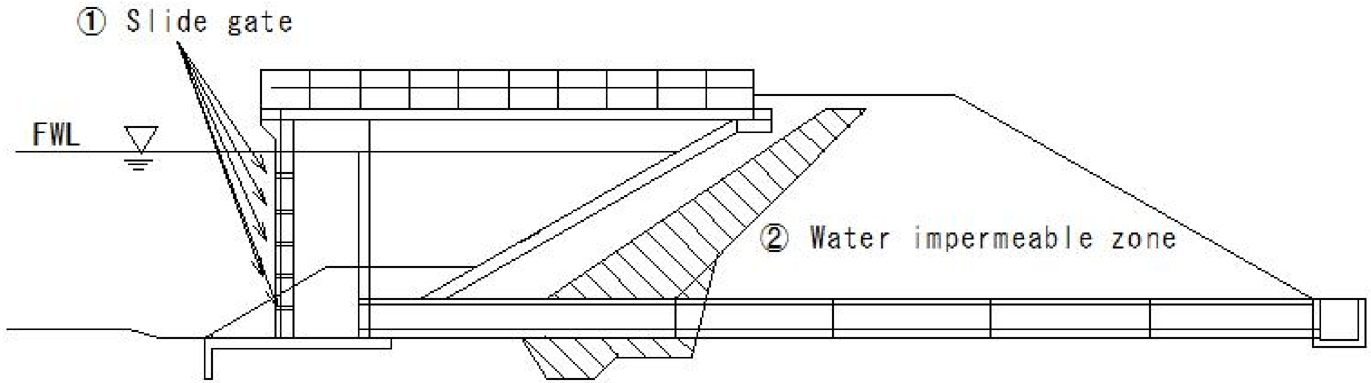


Figure 3.5.2 Water Intake Tower

I1392