Renovation of Taishakugawa Dam
(Shin-Taishakugawa Power Station Project)

THE CHUGOKU ELECTRIC POWER CO.,INC.

Energia
中国電力株式会社
THE CHUGOKU ELECTRIC POWER CO.,INC

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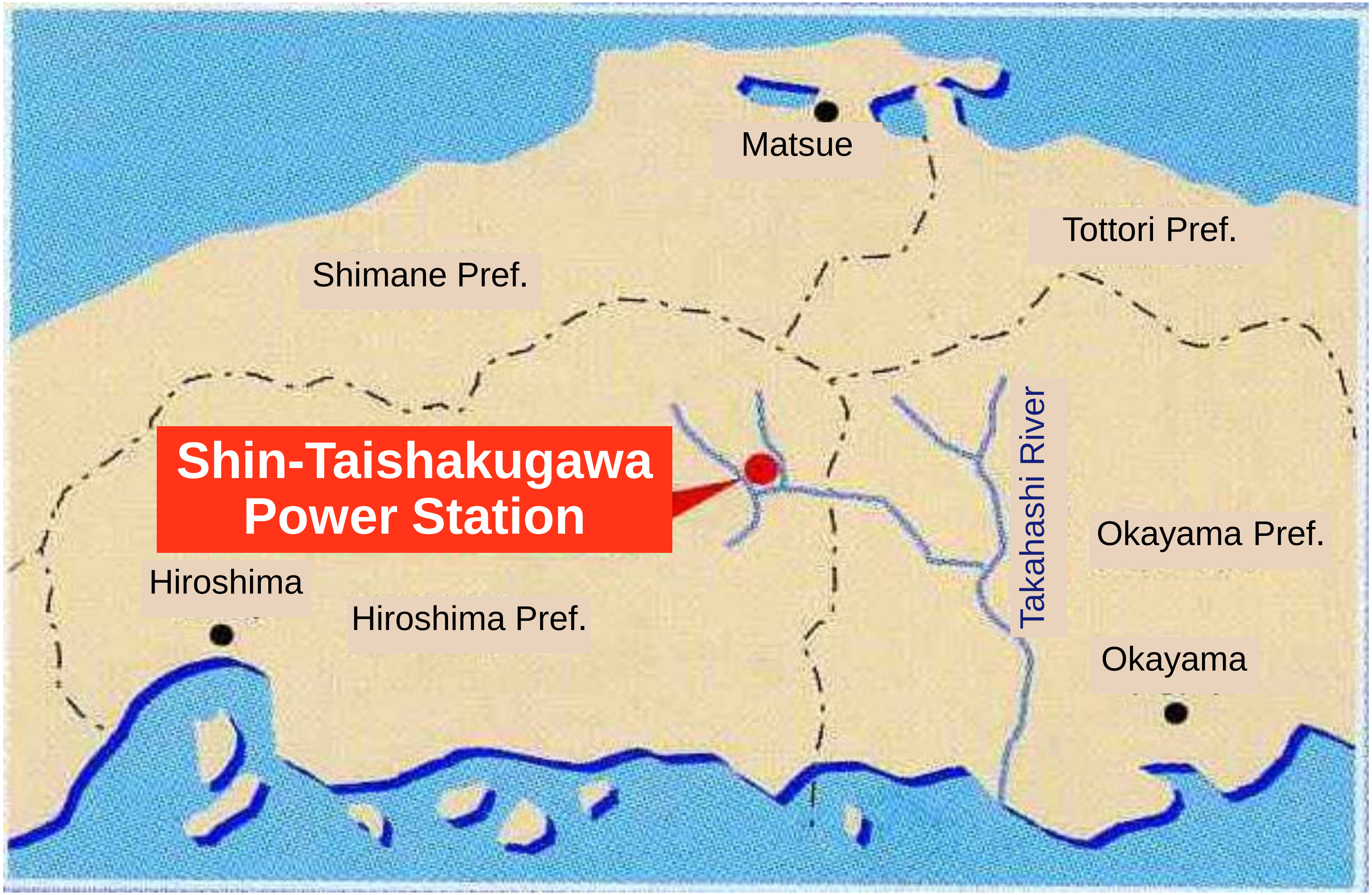
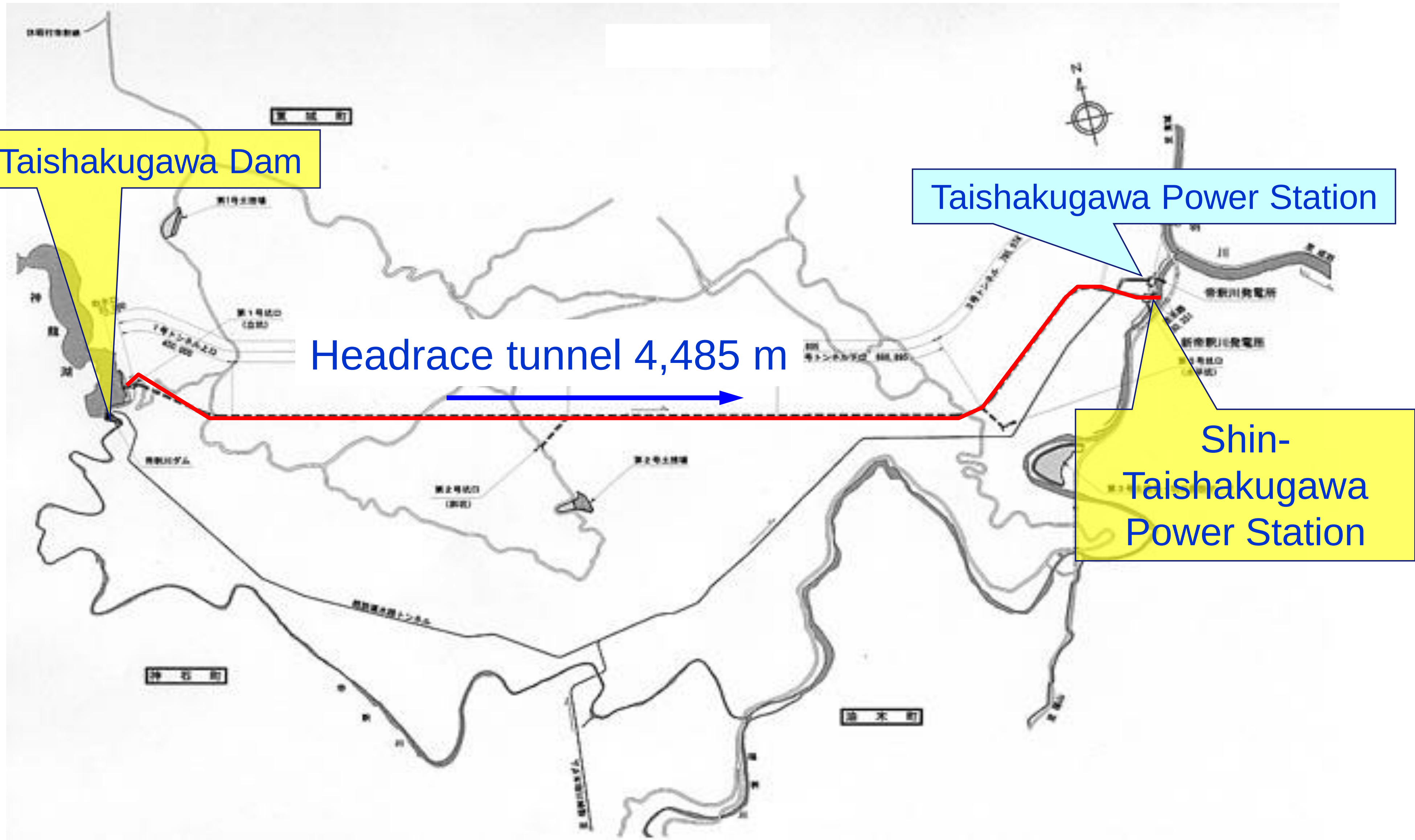
Location of the Shin-Taishakugawa Power Station



Shin-Taishakugawa Power Station - Headrace Plan



Shin-Taishakugawa Power Station - Specifications

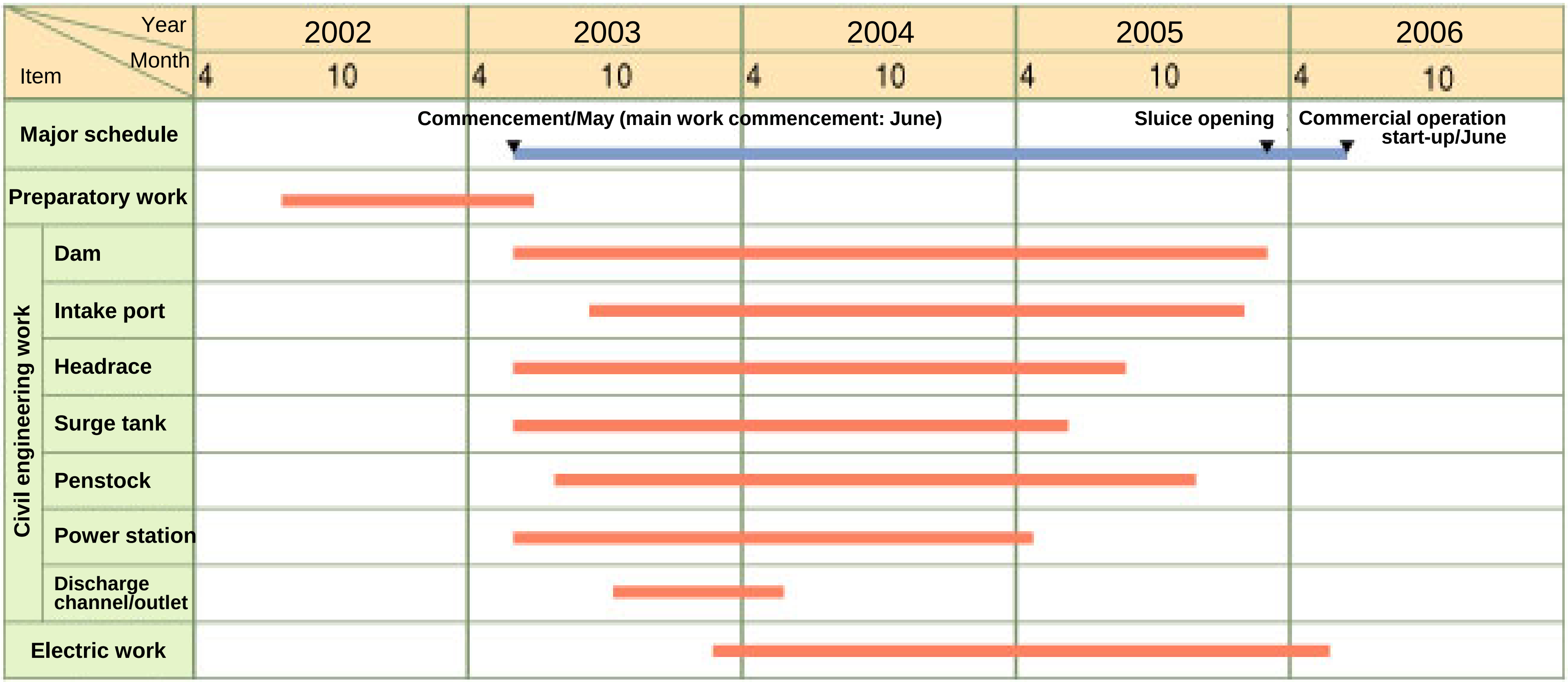
	Before redevelopment
Power station	Taishakugawa Power Station
River (River system)	Taishaku River and Fukumasu River (Takahashi River system)
Power generation method	Dam and conduit type
Catchment area	213.2 km^2
Maximum output	4,400 kW
Maximum discharge	5.7 m^3/s
Effective head	95.17 m

After redevelopment	
Shin-Taishakugawa Power Station	Taishakugawa Power Station
Taishaku River (Takahashi River System)	Fukumasu River (Takahashi River System)
Dam and conduit type	Conduit type
120.0 km^2	92.0 km^2
11,000 kW	2,400 kW
10.0 m^3/s	3.1 m^3/s
129.0 m	95.17 m

Construction Schedule

■Major milestone

Commencement: May 2003
Start of Commercial operation: June 2004



1. Overview of the Power Station Project

2. Design and Execution of Dam Renovation

3. Environmental Conservation Measures

History of the Taishakugawa Dam

- 1920 Commencement (Implementer: Sanyo Chuo Suiden)
  ⇨Power transmission to Kansai and Okayama areas

- 1924 Completion (Dam height: 56.4 m)
  * Japan's highest dam in those days
  [Reference: Oi Dam (completed in 1924: 53.4 m)]

- 1931 Dam height increased by 5.7 m (dam height: 62.1 m)
  ⇨Remains the same today

- 1966 Renovation of Spillway
  (111 wooden tumble gates → 2 steel roller gates)

Characteristics of the Taishakugawa Dam (1)—Dam Site

Unprecedented dam shape

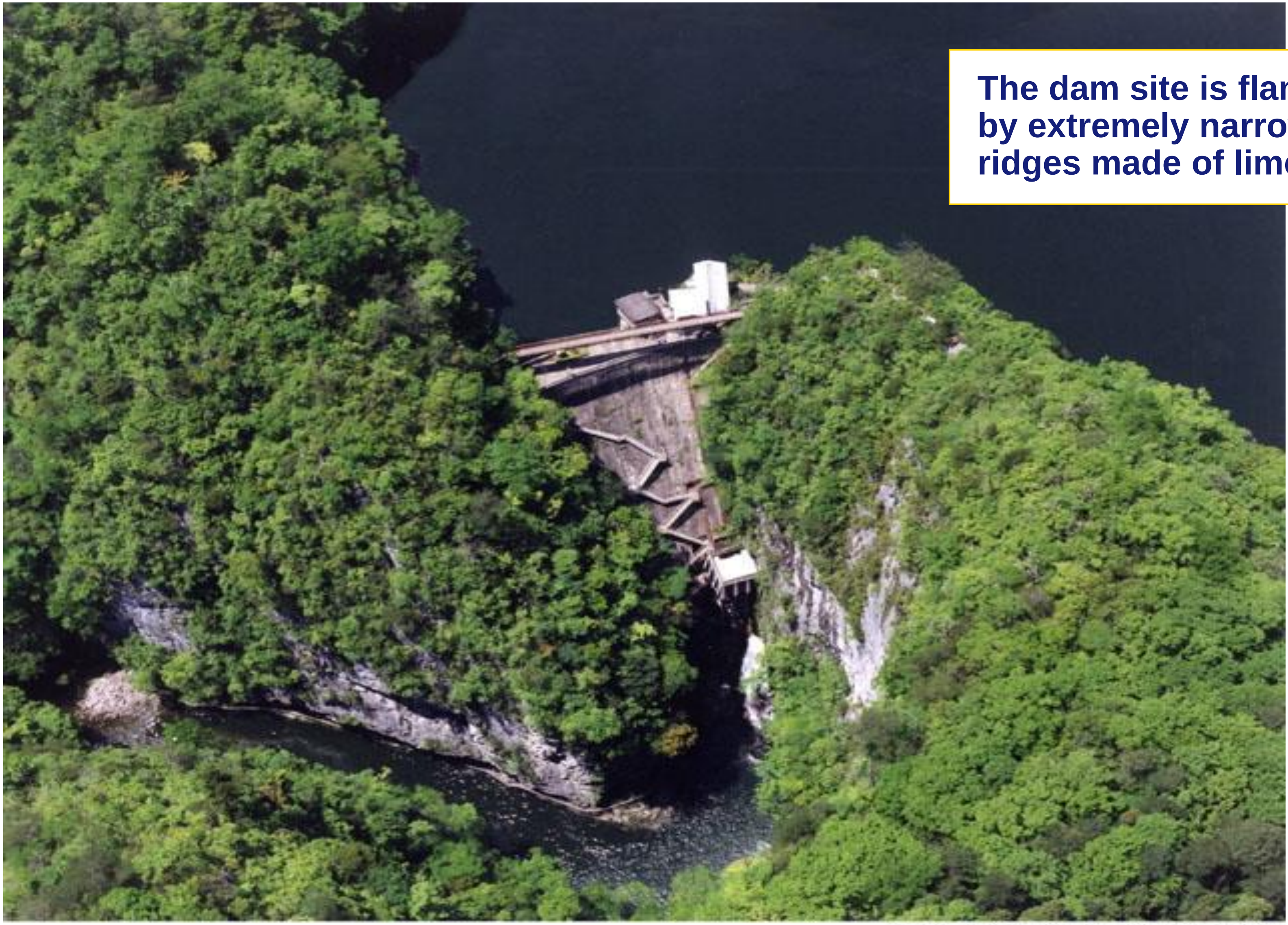
- Crest length is half the height.
- It is like a wedge when seen from the front.

Extremely high storage efficiency

- Total storage capacity :14,278,000 m^3 , Effective storage capacity :12,995,000 m^3 (Dam volume :31,000 m^3)
- Storage efficiency (effective capacity / dam volume) is the fourth highest in Japan (gravity dam).

Rank	Storage efficiency	Dam	Location	Owner
1	915.5	Uryu Daiichi	Hokkaido	The Hokkaido Electric Power Co., Inc.
2	695.6	Hanayama Dam (redevelopment)	Miyagi	Miyagi Prefecture
3	423.8	Yubari Shuparo	Hokkaido	Hokkaido Regional Development Bureau
4	419.1	Taishakugawa	Hiroshima	Chugoku Electric Power Co., Inc.

Topography of the Taishakugawa Dam Site (Downstream Side) [Aerial Photo]



The dam site is flanked by extremely narrow ridges made of limestone.

Photo of the present status - Viewpoint (6): Aerial photo showing the power plant seen from above the downstream sideよりみた写真

Topography of the Taishakugawa Dam Site (Upstream Side) [Aerial Photo]

Photo of the present status - Viewpoint (5): Aerial photo showing the power plant seen from above the downstream side

Taishakugawa Dam (Photo Taken From Downstream)

Taishakugawa Dam (Photo Taken from Upstream)

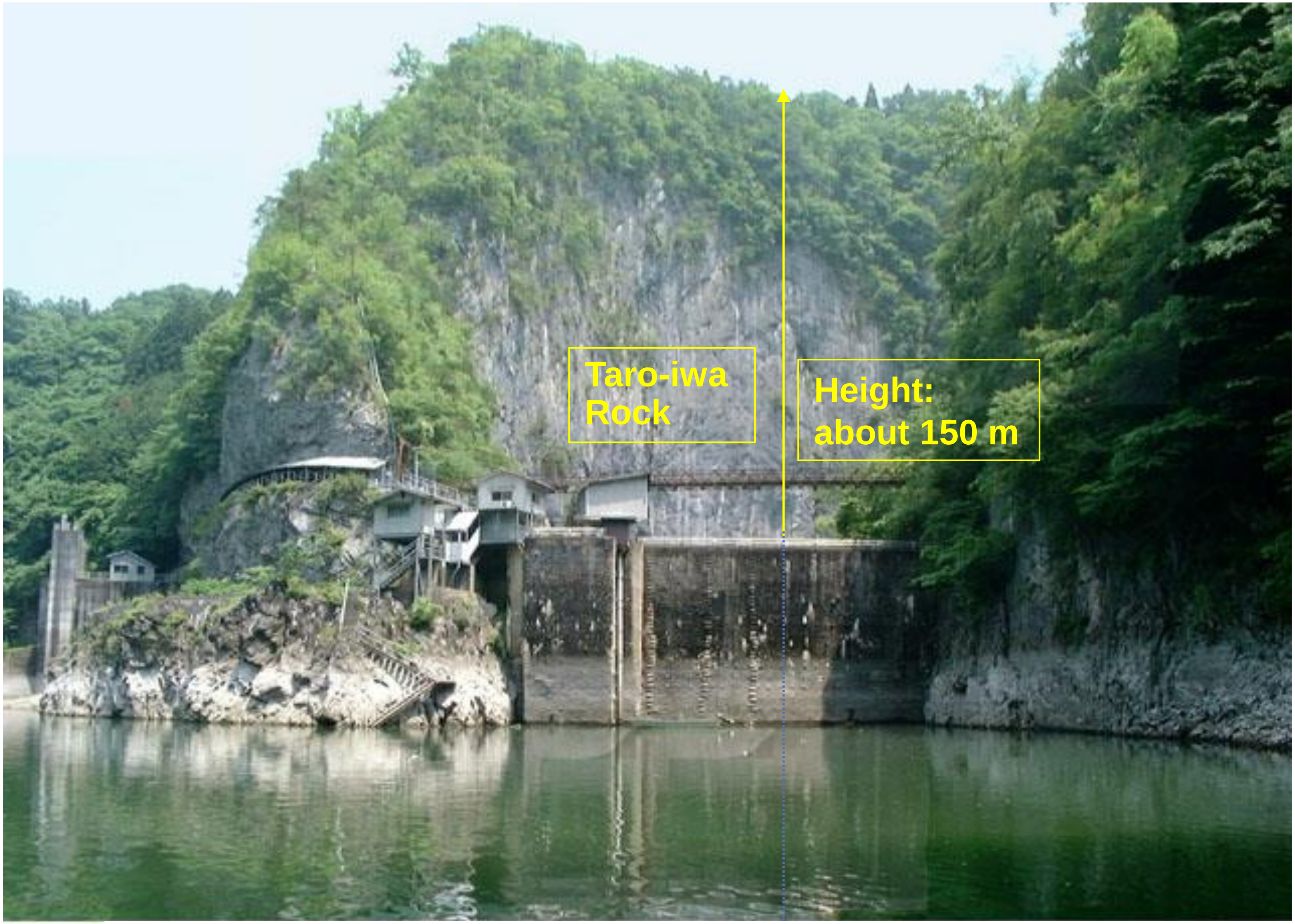


Photo of the present status - Viewpoint (2): Photo showing the dam and the Taro-iwa Rock from the sightseeing boat position (staged straight line plan)

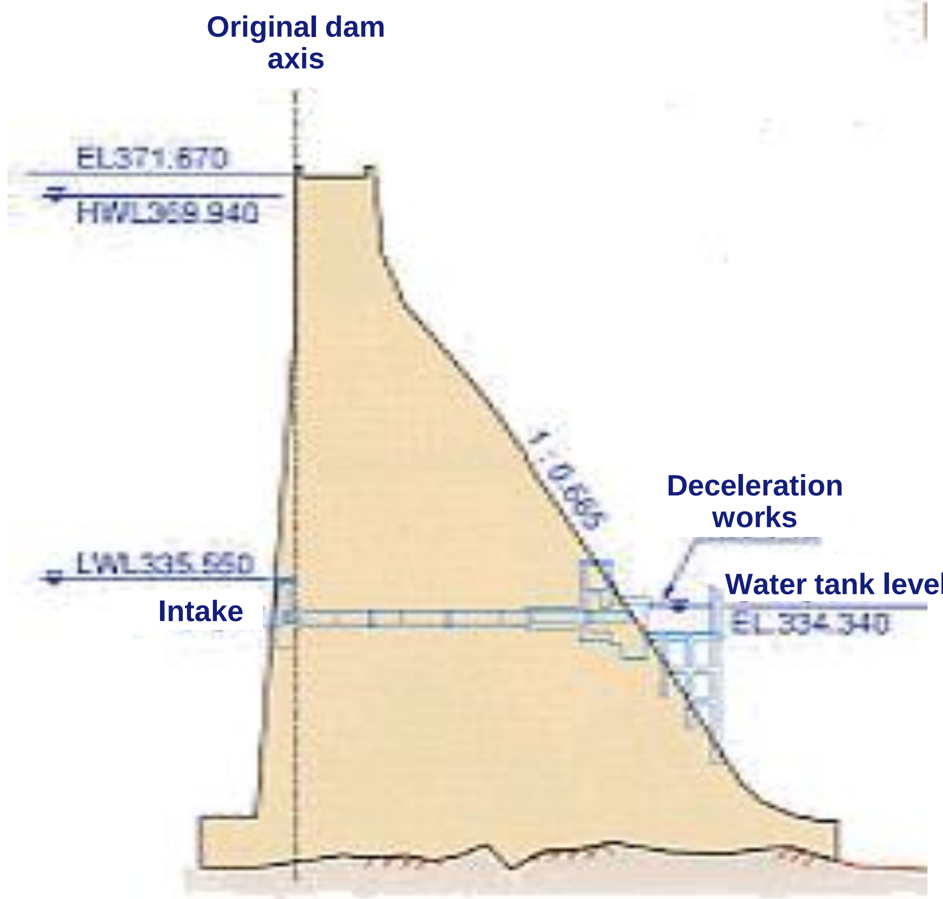
Characteristics of the Taishakugawa Dam (2)—Dam Body

Characteristics of Dam Body

- Upstream gradient: 1:0.0745
  Downstream gradient: 1:0.665
- Seismic force was not considered in the dam stability calculation.
- The surfacing is stone finish.
- Arch shaped in plan
- No lateral joints

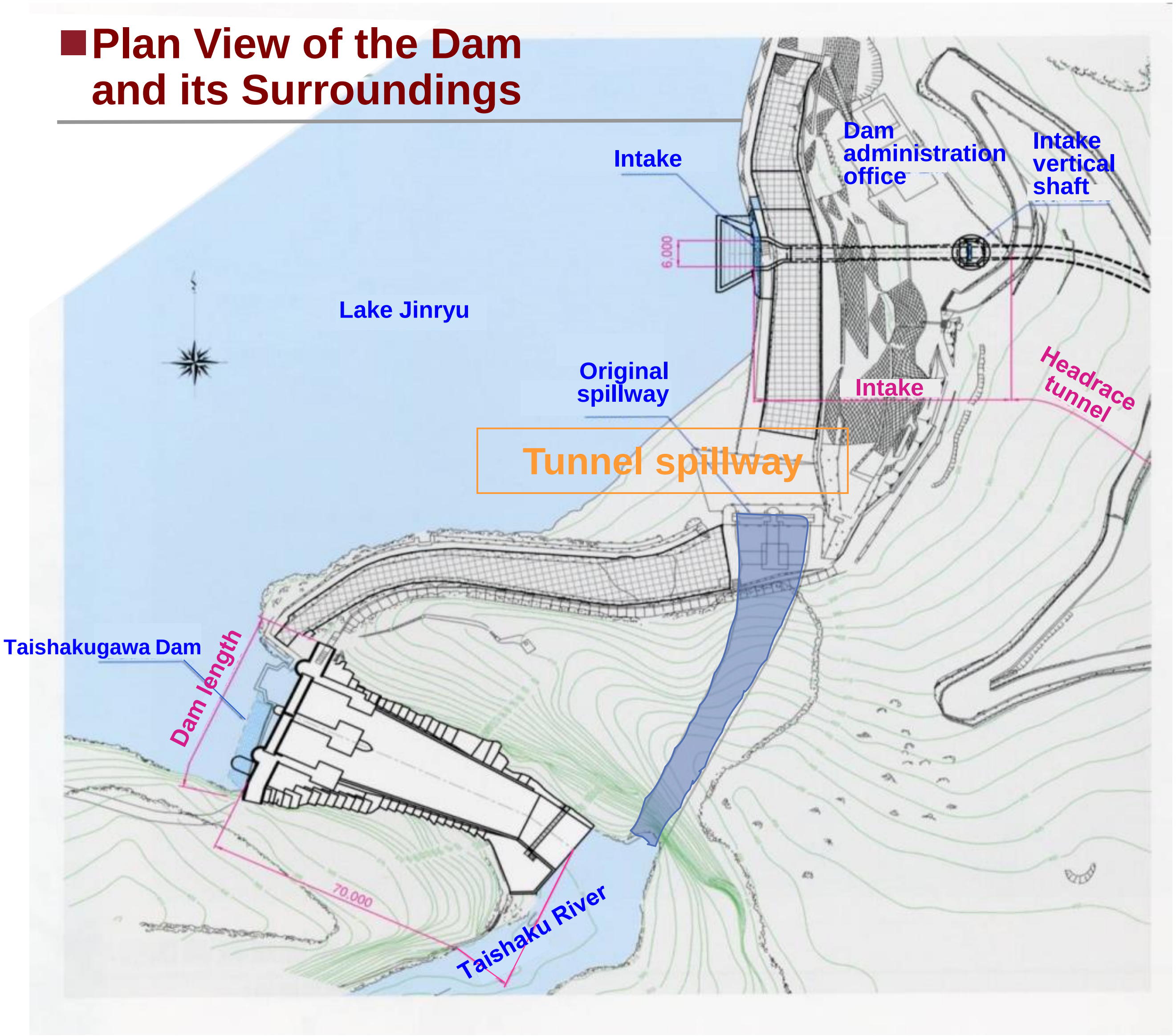
Spillway is a tunnel type

- It was installed separately from the dam.



Taishakugawa Dam—Plan View of the Surrounding Area

■Plan View of the Dam and its Surroundings



Tunnel Spillway (existing)

Inlet
(two roller gates)

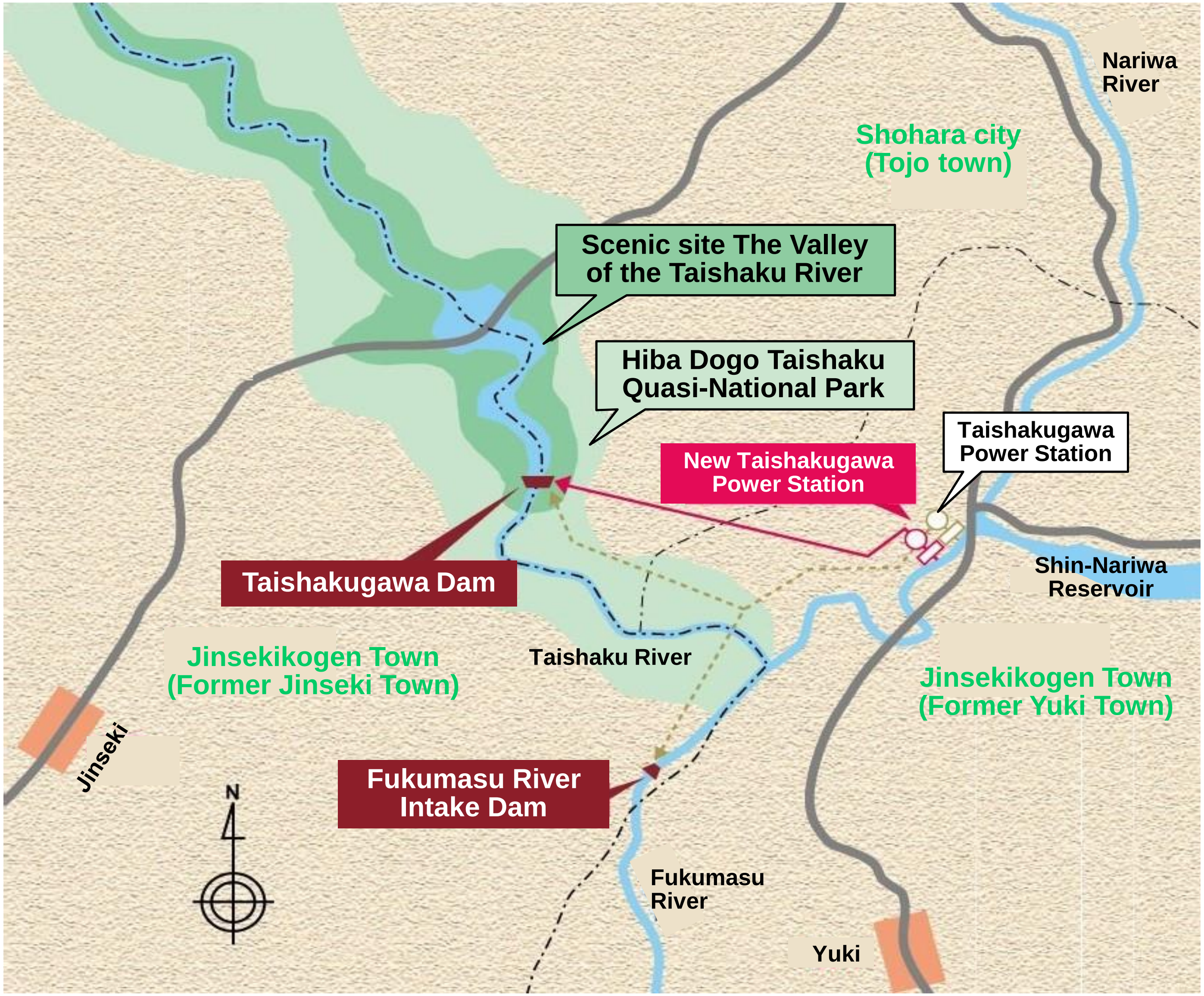
Outlet

Tunnel
(internal diameter: about 7 m)

Characteristics of the Taishakugawa Dam (3)—Locational Environment

- **Government-designated scenic place "Valley of the Taishaku River (Taishaku-kyo)"**
  - Act for the Protection of Cultural Properties
  - Designated in 1923
- **Hiba, Dogo and Taishaku Quasi-National Park (Type 1 Special Zone)**
  - Natural Parks Act
  - Designated in 1963
- **One of the most famous sightseeing spots in Hiroshima Pref.**
  - Annual tourist turnout: about 700,000 (particularly autumnal leaves attract tourists)
  - Sightseeing boats cruise in the reservoir.
  - The reservoir itself is a valuable sightseeing resource.

Map of Legal Restrictions around the Dam and its Reservoir



Reservoir (Lake Jinryu) and Sightseeing Boat [Autumn]

Reservoir (Ryujin Lake) and Sightseeing Boat [Spring]

Lake Opening (April 29)

Taishaku-kyo—Onbashi [National Monument: One of the World's Top Three Natural Bridges]

Total length: 90 m

Width: 18 m

Height: 40 m

Taishakugawa Dam—Necessity of Preservation Measures

- **Deterioration**
  - **The dam is already over 80 years old since its completion in 1924.**
- **The discharge capability of the existing spillway tunnel is insufficient.**
  - **The reservoir water level should be lowered in advance during the flood season to control the discharge volume.**
- **The head, maximum 35 m, is untapped.**
  - **No effective use of valuable water resource is made.**

The solution is to conduct radical repair in coordination with the redevelopment program of the power plant so as to remodel the dam into a modern one.

Taishakugawa Dam - Outline of the Preservation Works

Increasing the flood control capability

- Additional installation of dam overflow spillways
- Increase of flood control capability from 720 m^3/s to 1610 m^3/s

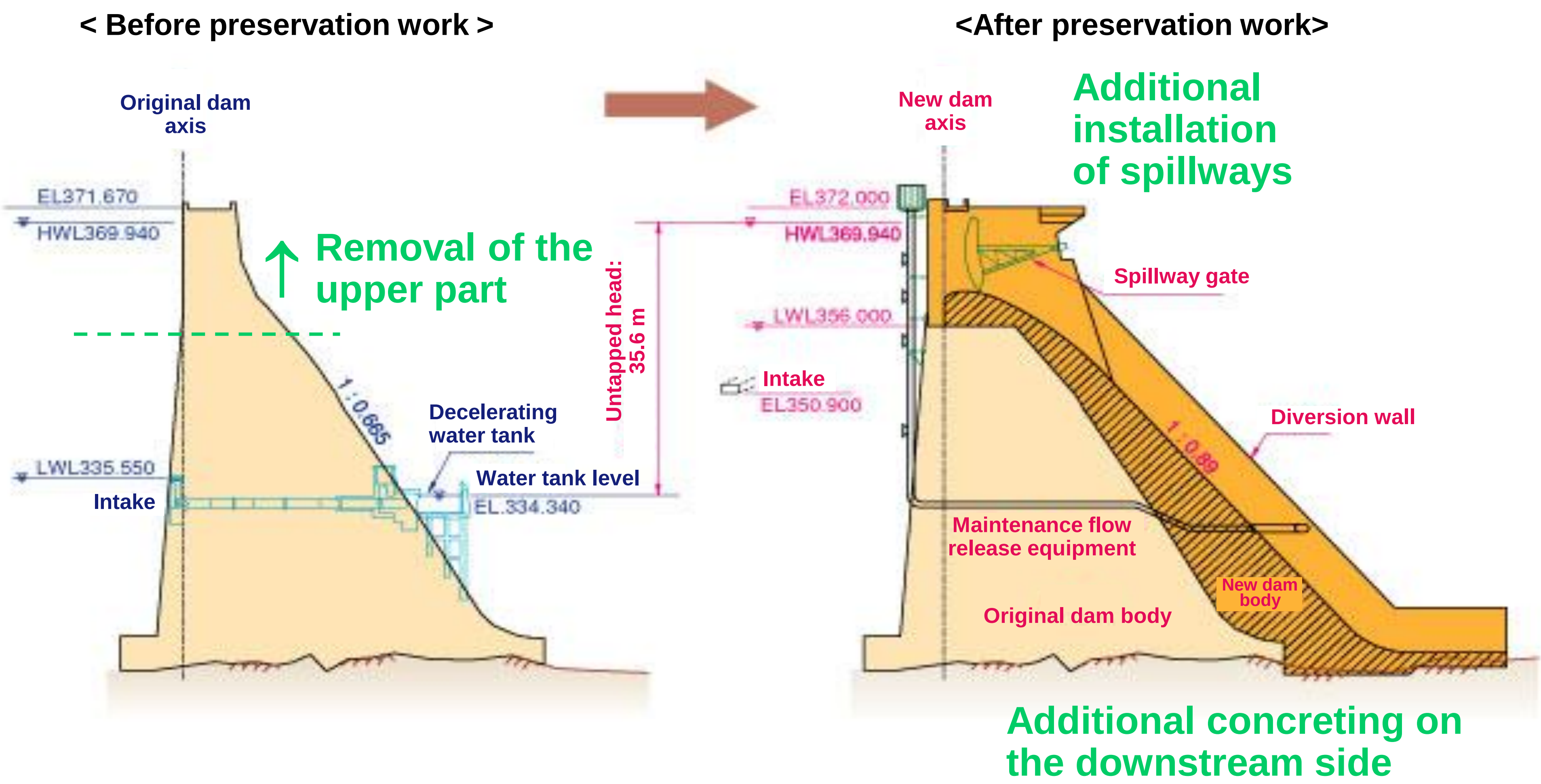
Improving the dam stability

- Additional concreting on the downstream side of the existing dam body
- Increasing the gradient of the downstream side of the dam from 1:0.665 to 1:0.89

Complying with the current design code

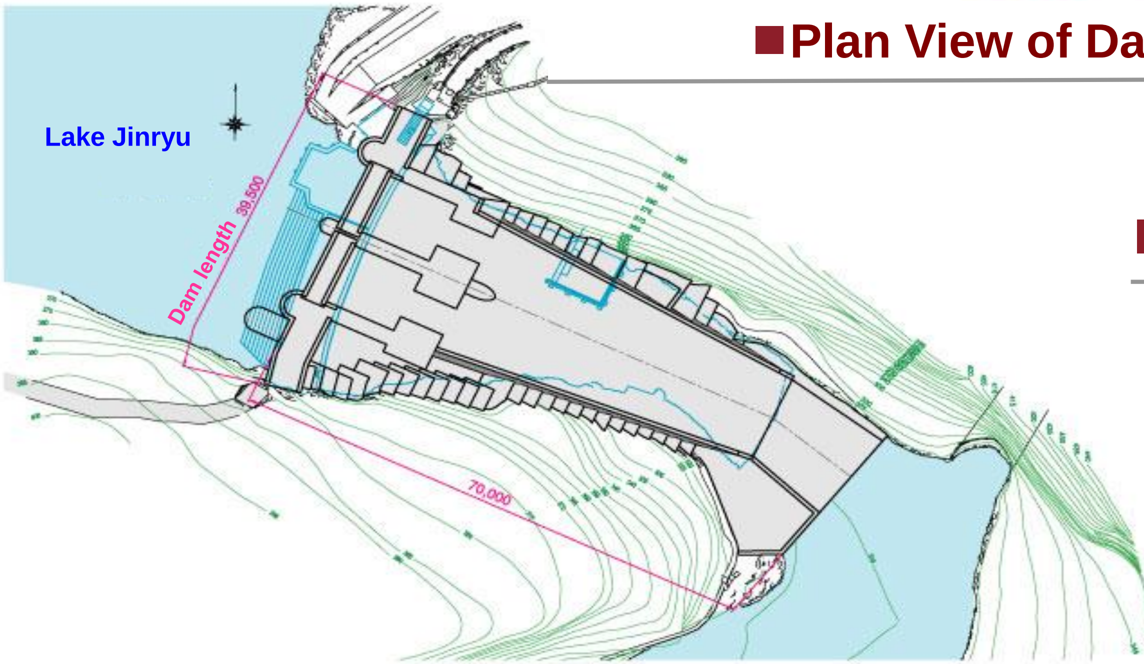
Taishakugawa Dam—Schematic Illustration of the Preservation Works

■Sectional View of the Taishakugawa Dam

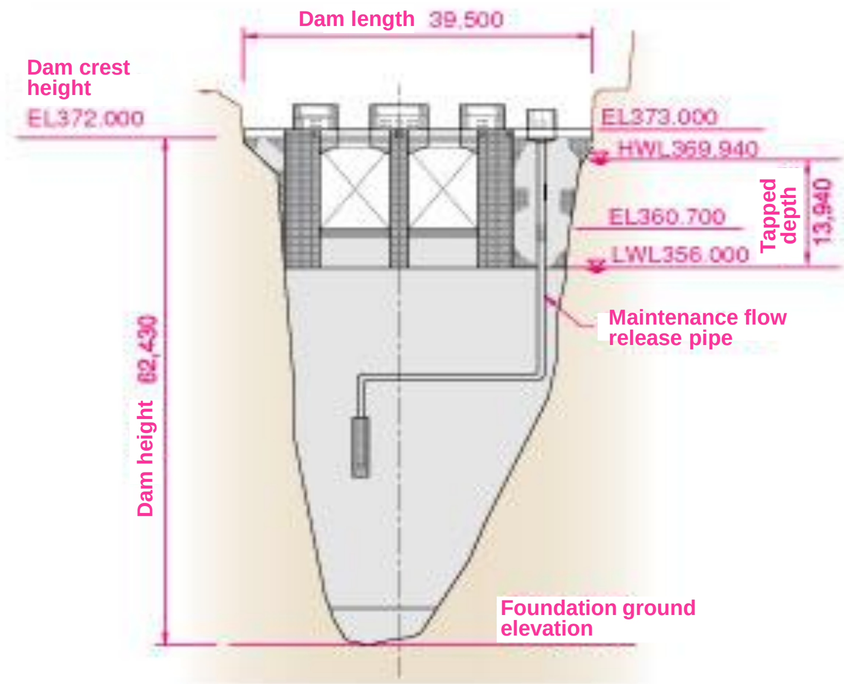


Dam Design Drawing (Plan and Upstream Plan)

■Plan View of Dam



■View of Dam Upstream Side



Specifications of the Taishakugawa Dam

Item	Before repair	After repair
Type	Concrete gravity	Same as left
Dam height	62.1 m	62.43 m
Dam volume	31,000 m^3	45,000 m^3
HWL	EL. 369.94 m	EL 369.94 m
LWL	EL. 335.55 m	EL. 356.00 m
Effective storage capacity	1.3 million m^3	7.5 million m^3
Flood control capability	720 m^3/s	1,610 m^3/s
Flood control method	Tunnel spillway: 720 m^3/s	Tunnel spillway: 720 m^3/s Dam overflow spillway: 890 m^3/s

Taishakugawa Dam - CG of the Completed Dam

Photo of the present status - Viewpoint (6): Aerial photo showing the dam from above the downstream side

Integrity Evaluation of the Existing Dam

1. The original dam body was a boulder concrete dam covered with rubble stone. (Concrete before the dam concrete technique was established.)

2. A lot of leakage occurred in early years after completion, but over ten grouting applications improved the condition, and currently almost no leakage occurs (only a few liters per minute).

3. Physical values of the original dam body concrete (confirmed by survey with three boreholes on the dam crest)

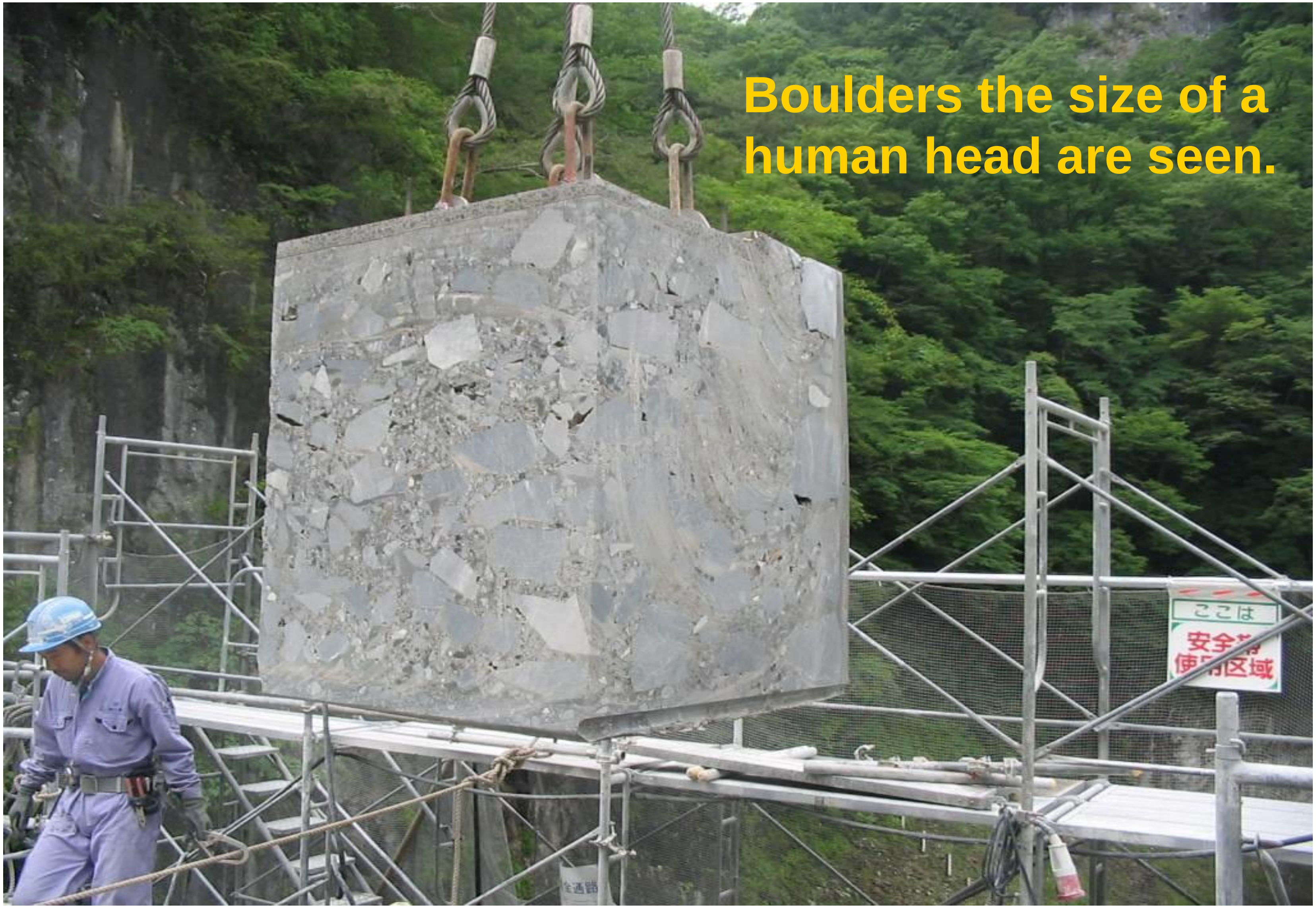
   - Unconfined compressive strength: 20 N/mm^2 (average)

   - Unit weight: 2.34 g/cm^3 (average)

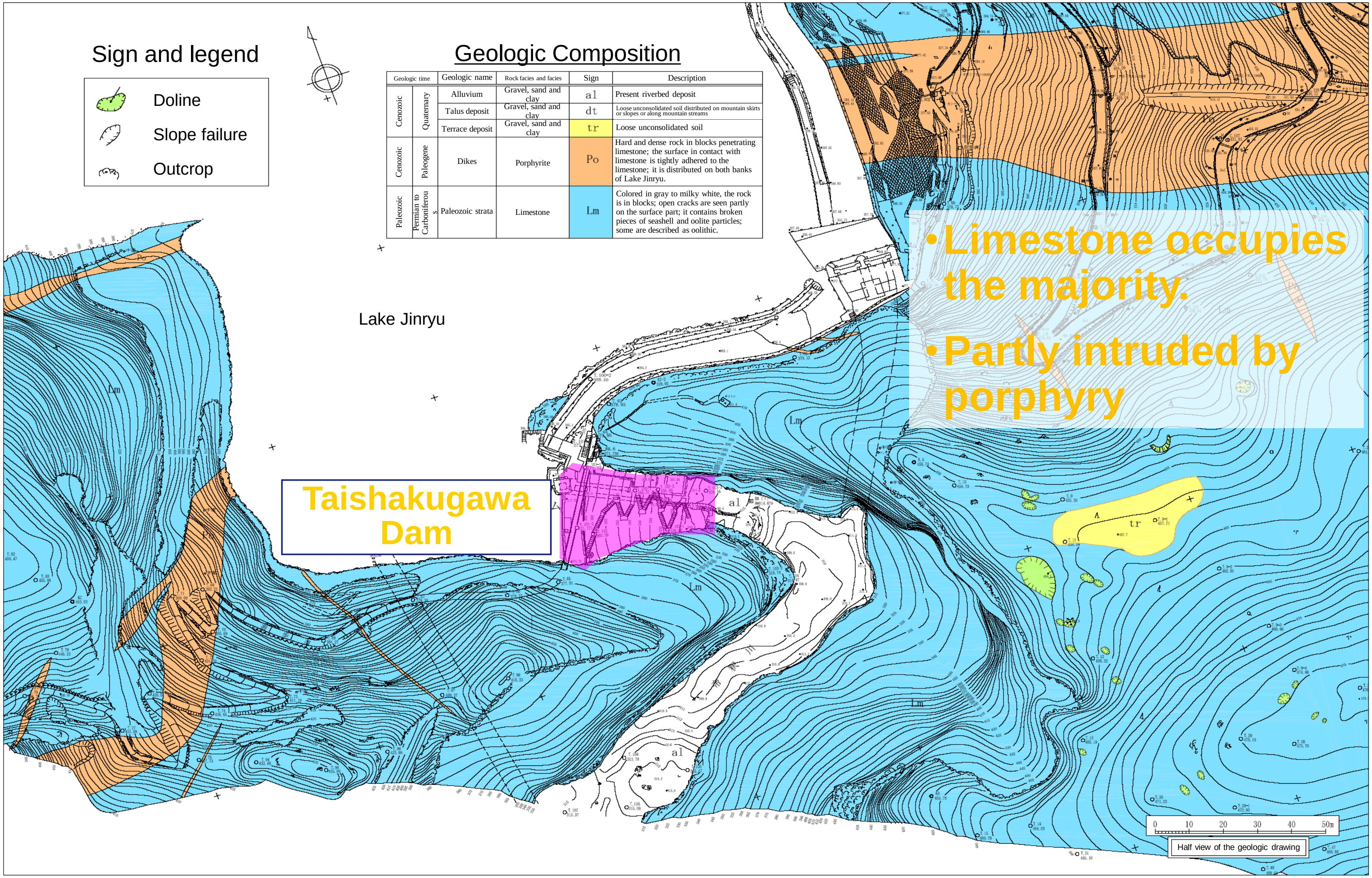
4. No neutralization occurred (the effect of the stone finish on the dam body?)

> *The existing dam body concrete satisfies the properties required of a dam concrete (water-tightness, strength, unit weight, etc.).*

Existing Dam Body Concrete



Geology around the Dam



- Limestone occupies the majority.
- Partly intruded by porphyry

Geologic Composition

Geologic time		Geologic name	Rock facies and facies	Sign	Description
Cenozoic	Quaternary	Alluvium	Gravel, sand and clay	al	Present riverbed deposit
		Talus deposit	Gravel, sand and clay	dt	Loose unconsolidated soil distributed on mountain skirts or slopes or along mountain streams
		Terrace deposit	Gravel, sand and clay	tr	Loose unconsolidated soil
Cenozoic	Paleogene	Dikes	Porphyrite	Po	Hard and dense rock in blocks penetrating limestone; the surface in contact with limestone is tightly adhered to the limestone; it is distributed on both banks of Lake Jinryu.
Paleozoic	Permian to Carboniferous	Paleozoic strata	Limestone	Lm	Colored in gray to milky white, the rock is in blocks; open cracks are seen partly on the surface part; it contains broken pieces of seashell and oolite particles; some are described as oolithic.

Rock Grade Distribution

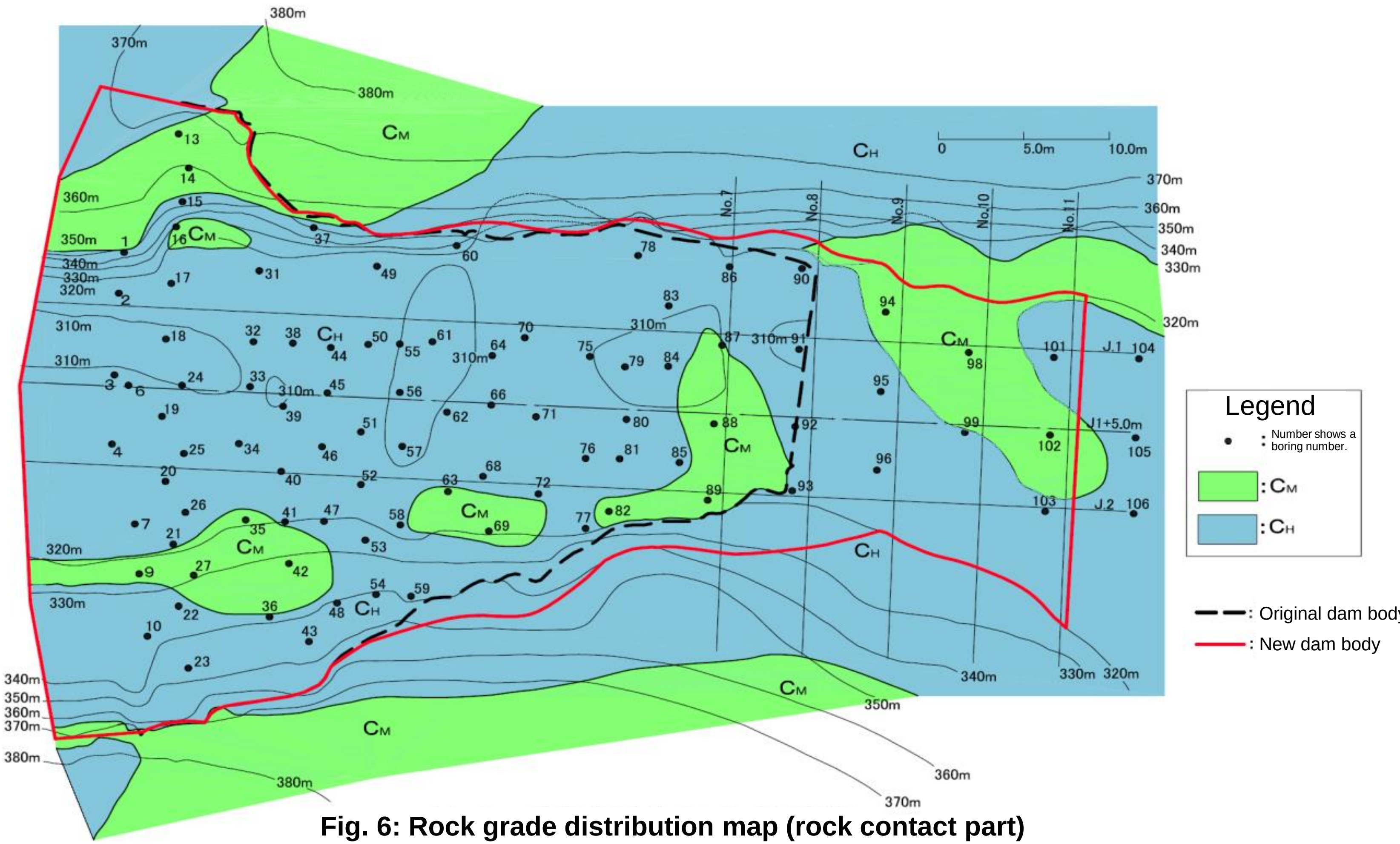


Fig. 6: Rock grade distribution map (rock contact part)

The rock foundation of the dam is mainly composed of good quality grade, CH.

Design of Spillway (1/3)

1. Background

A torrential rainfall occurred in the Sanin area and caused devastating damage in 1983. In response, the scale of a flood practically expected to occur was reviewed in detail.

As it turned out, it is possible that a flood that far exceeds the original release capability (720 m^3/s) would occur (about 1,000 m^3/s).

The Solution is to improve the dam's flood control capability by additionally installing spillways.

Design of Spillway (2/3)

• Design flood discharge

In compliance with the Cabinet Order concerning Structural Standards for River Management Facilities, the flood discharge by the Creager formula, 1,610 m^3/s, was adopted as the design flood discharge from above Creager discharge, the past maximum flood discharge and the 1/200 probability flood discharge.
The flow (890 m^3/s) that cannot be handled by the original tunnel spillway capability (720 m^3/s) should be handled by spillways additionally installed on the dam body.

[Reference]

i. Past maximum flood discharge: 659 m^3/s (July 12, 1972)

ii. 1/200 probability flood discharge: 690 m^3/s

iii. Discharge by Creager formulation: 1,610 m^3/s

Design of Spillway (3/3)

• *Elimination of Energy Dissipators*

Energy Dissipators such as an auxiliary dam were eliminated to reduce the natural area to modify and the cost.

[Grounds]

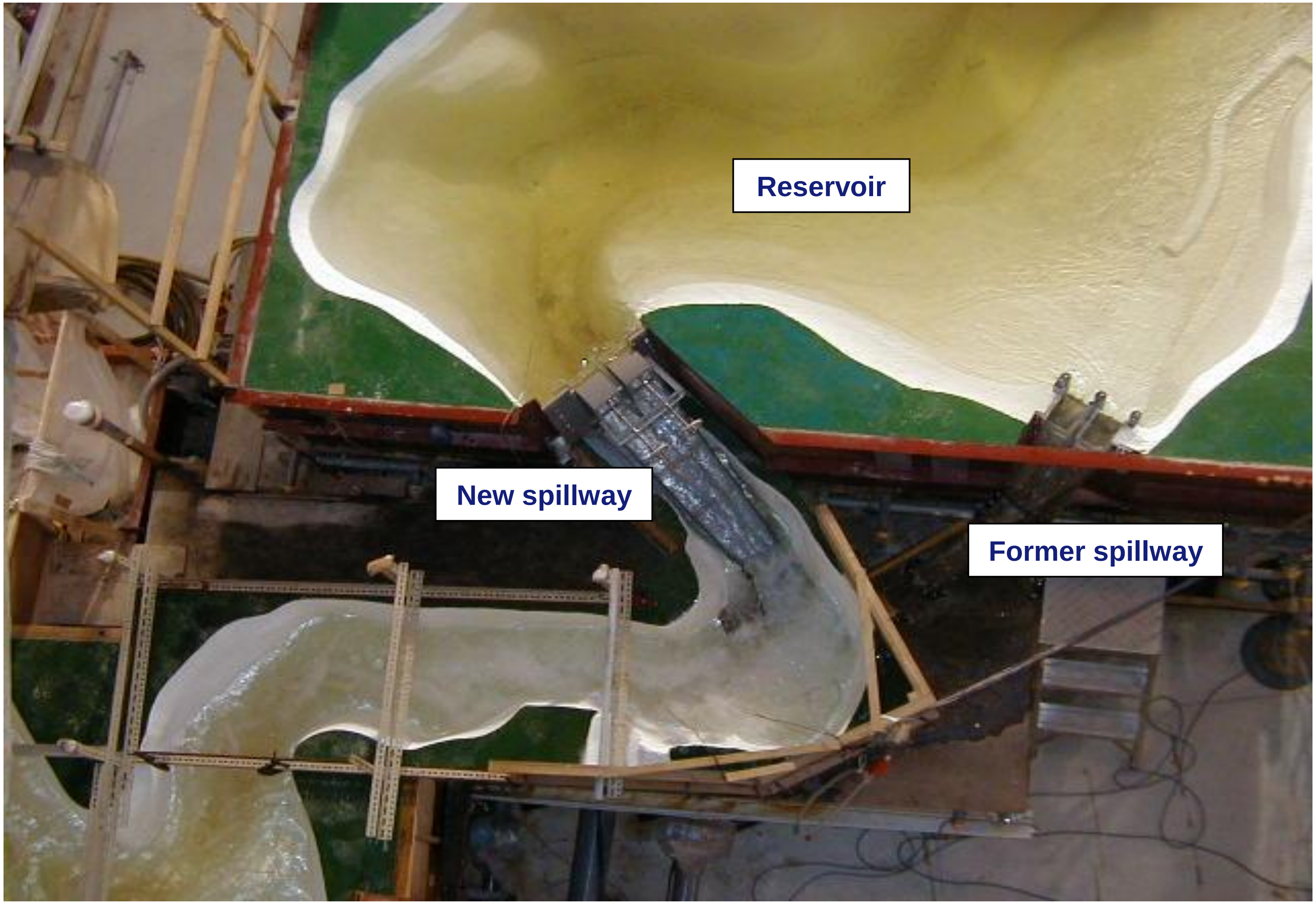
i. **No houses or important structures exist within a few kilometers in radius downstream of the dam. In addition, the flood release from the reservoir will be limited to a range of 200 m downstream of the dam because of topographic conditions.**

   → **Confirmed by hydraulic model experiment**

ii. **Sound rock foundations are exposed on both banks downstream of the dam, which indicates almost no possibility of a major failure of the river bank even if flood release takes place.**

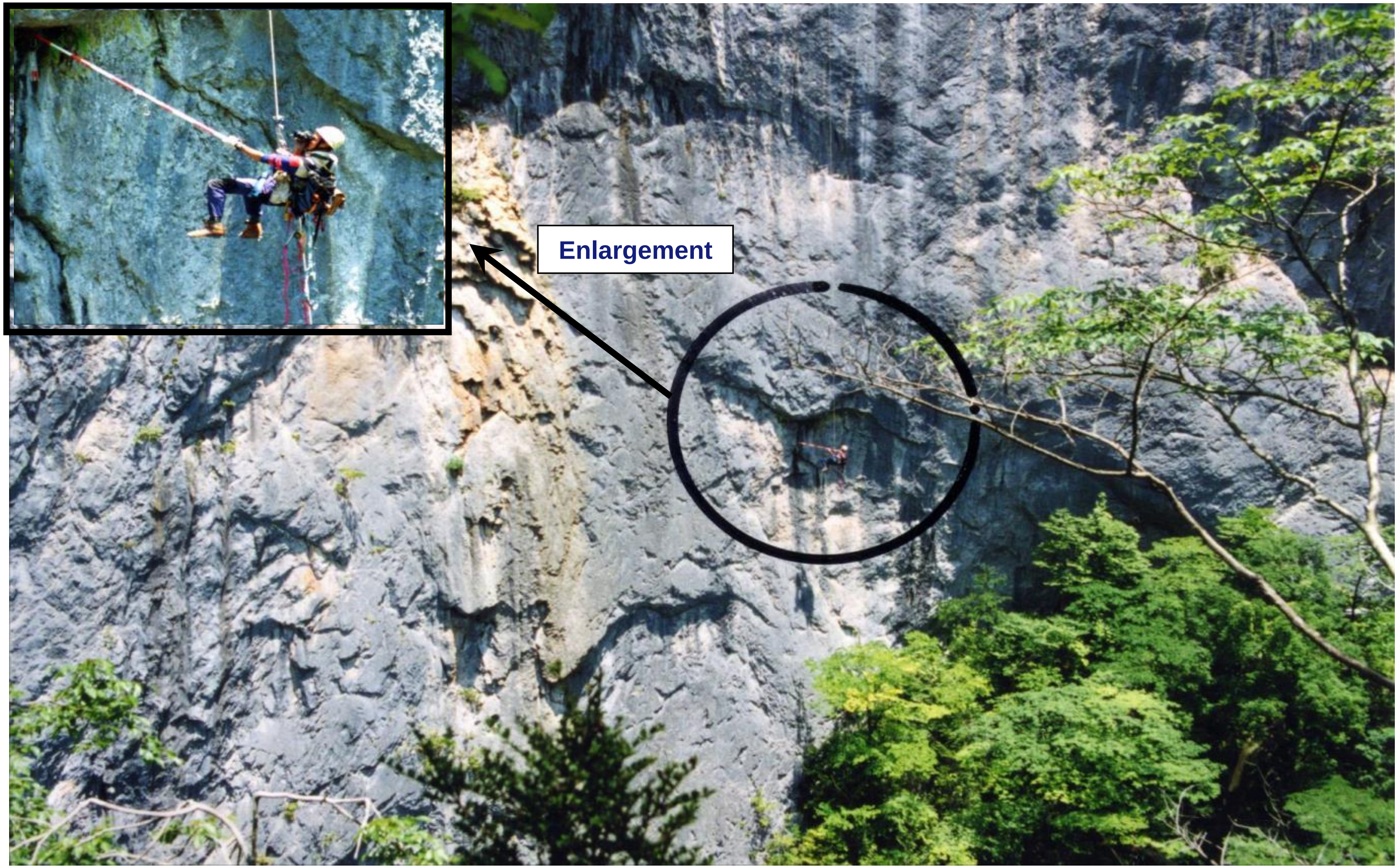
   → **Confirmed by geologic survey**

Hydraulic Model Experiment



(Model scale - 1:60)

Geological Reconnaissance



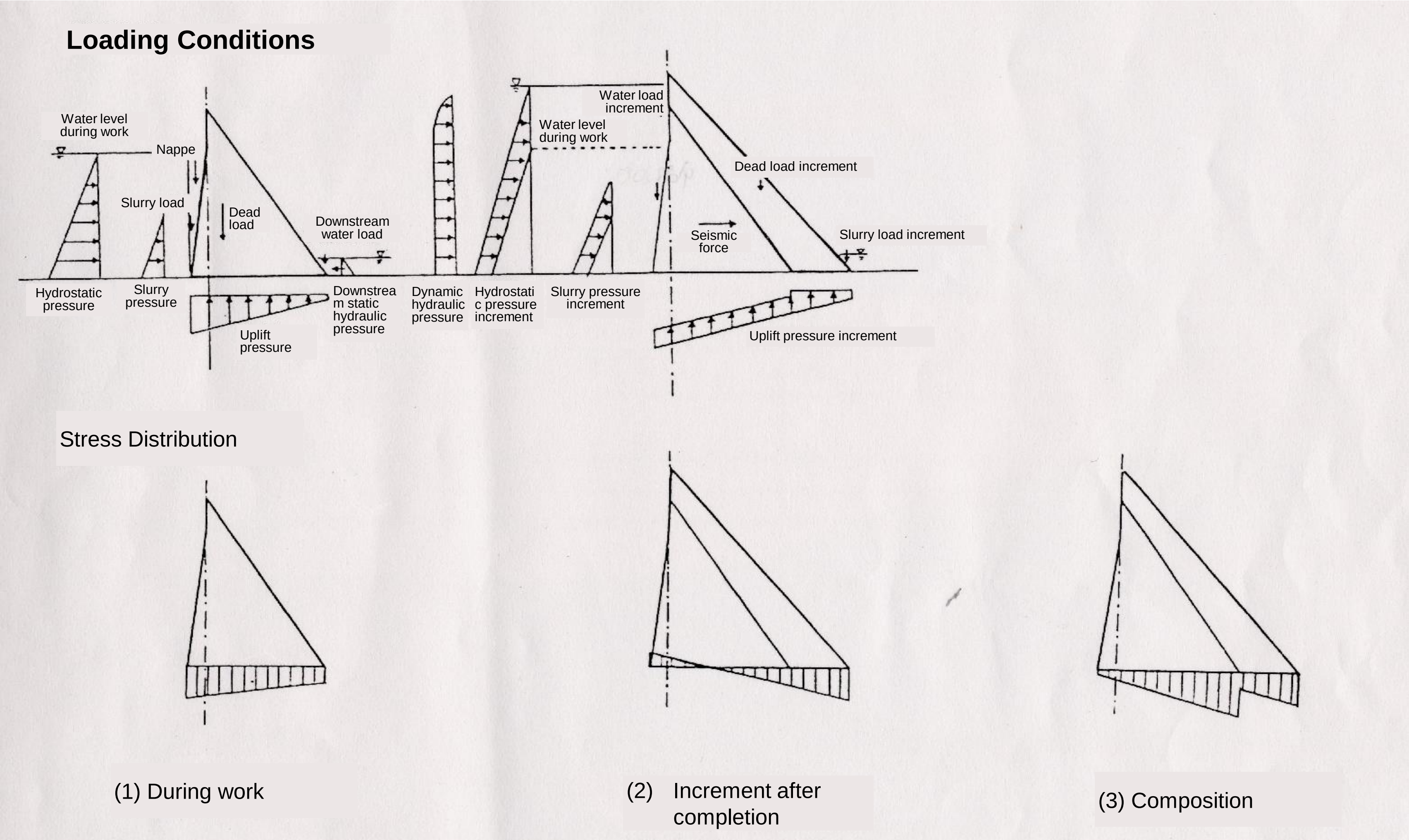
Dam Body Stability Calculation (Design Theory)

The stability design was conducted based on "Kakitani's dam enlargement formula" that considers the condition that dam enlargement will be conducted based on the reservoir impounding condition.

"Kakitani's dam enlargement formula"

- **A formula derived from the rigid body theory based on the basic idea that the load during construction work is sustained by the former dam body and that the new load to be added after completion is sustained jointly by the new and former dam body.**
- **This idea was applied to our Odomari Dam (completed in 1959) for the first time and has been used for the majority of dam enlargement projects since then.**

Kakitani Formula's Basic Idea



Principle of Kakitani's Formula

Why Kakitani's Formula was Used

- Considering the fact that the reservoir is used for sightseeing purpose, the construction work should be conducted with the reservoir filled with water, but in this case, it is necessary to consider the impact of water storage on the original dam body, and it is not appropriate to apply the new dam construction design principle.

- The basic idea that the load during the work is to be sustained by the original dam body and that the new load added after completion to be sustained jointly by the new and old dam bodies is considered to be applicable as is to this work. Therefore, it is appropriate to use the design based on the idea of Kakitani's formula although no dam enlargement work is included.

Determination of the Downstream Gradient

The water level during the work is the biggest factor to determine the downstream gradient according to Kakitani's formula.
⇨The lower the level during work, the steeper the downstream gradient can be.

[What should be considered in determining the water level during work]

- **The lower the level during work, the better.**
  - •It allows reduction in the natural area to be modified.
  - •It allows control of flooding during work.

- **The higher the level during work, the better.**
  - •It allows sightseeing boats to be operated.

[Determination of the water level during work]

Minimum level that allows safe operation of sightseeing boats: EL 350 m (20 m down from HWL) plus 2 m allowance to set the water level during the work in terms of design calculation to EL 352 m.

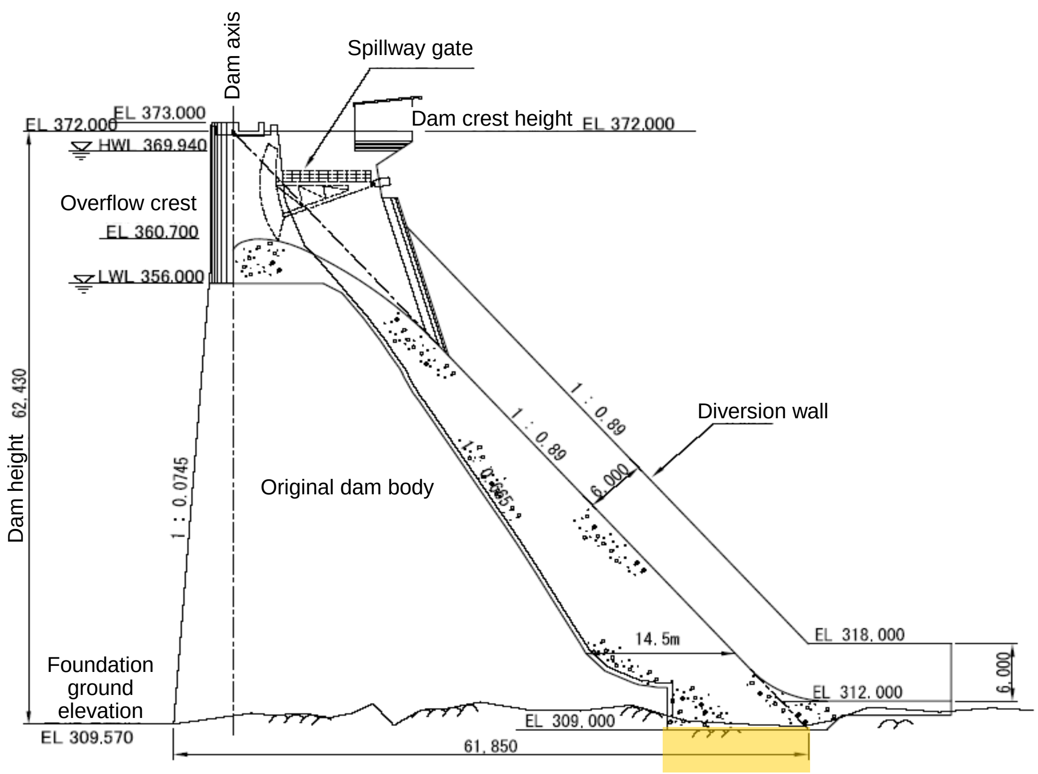
Downstream Gradient: 1:0.89

Consolidation Grouting

Apply consolidation grouting to the area that becomes a new dam foundation.

It is confirmed by boring that the foundation of the original dam body is low in permeability.

Dam Standard Section



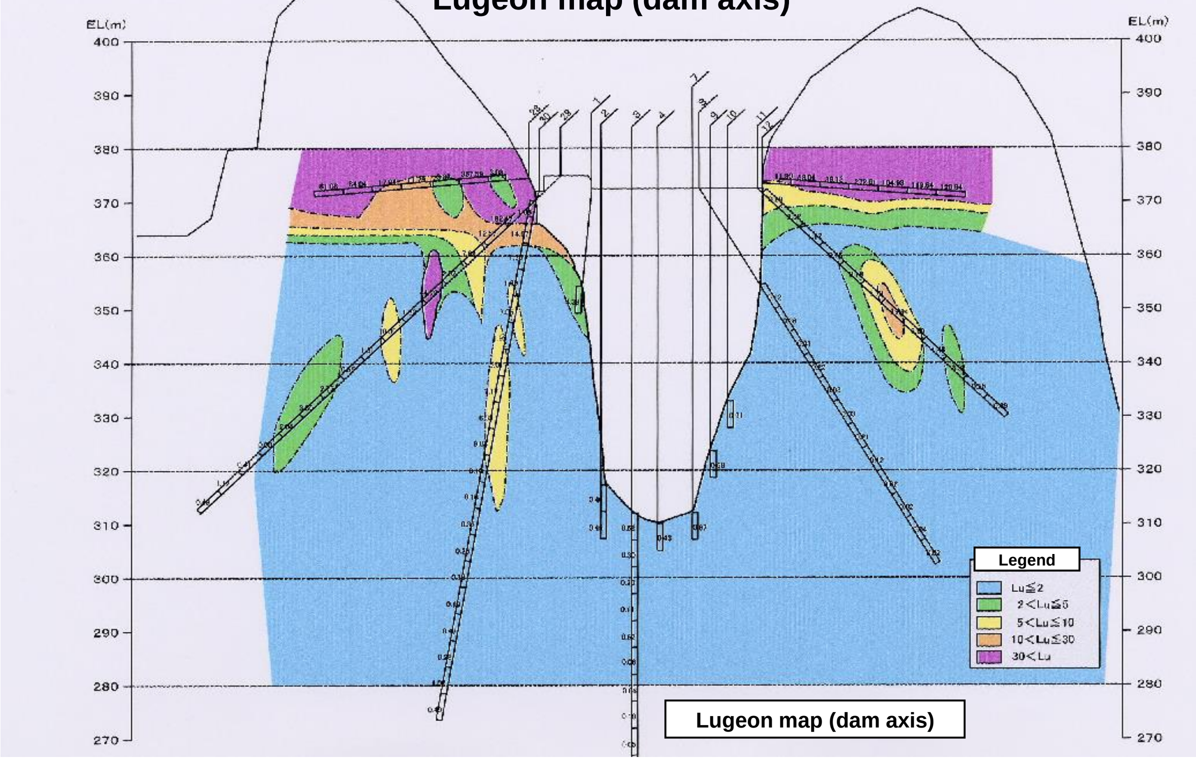
Curtain (Rim) Grouting

No curtain (rim) grouting

[Reason]

Although there is a part with high permeability (20Lu or more) in the higher part of the original dam body, no HWL change should be allowed, and no leak that may hinder operation would occur as a result of the investigation of the area around the dam with the reservoir fully filled on an experimental basis. Therefore, no curtain grouting would be conducted.

Lugeon map (dam axis)



Dam Concrete (Characteristics)

- Since the total amount of concrete placed is not so much, or about 15,600 m^3, an existing ready-mixed concrete plant should be used [for cost reduction].

  [Reviews]
  - Concrete production capability
  - Transport time from production to placement
  - Impact on concrete supply, etc.

- The maximum aggregate size of 40 mm should be determined based on the detailed mixing test, thermal stress analysis, and workability tests for compaction, etc. [for cost reduction].

- Moderate heat fly ash cement (30% fly ash replacement rate) should be adopted for cement [for environmental conservation].

Dam Concrete (Concreting Method)

- **Transport**

  Transport from the local ready-mixed concrete plant to the dam site on an agitator vehicle (traveling distance: about 13 km)

- **Concreting**

  Concreting with bucket (2.25 m^3) using an 80-ton crawler crane installed on the temporary platform on the downstream side.

- **Concreting method**

  Joint use of extended layer construction method and block layer construction method

- **Concreting lift**

  1m (50 cm × two layers)

Dam Concrete (Mixing Review)

1. Mixing conditions

- Strength
  Match the strength of the original dam body (20 N/mm2) to ensure monolithic structure of the new and old dam body.
- Durability and water-tightness
  Water-binder ratio should be not more than 60% since mixing is conducted outside the site.
- Slump and air ratio
  The appropriate mixing that considers workability should be used.

2. Determination of mixing

- Cement used: Moderate-heat flyash cement
- Max. coarse aggregate dimension: 40 mm
- Slump: 4.0 ± 1.0 cm (8.0 ± 2.5 cm for the structural parts)
- Air volume: 4.0 ± 1.0%
- W/C: 60%

	Water	Cement	Fine aggregate	Coarse aggregate	Remarks
Dam body	147	245	741	1178	
Structure	165	275	750	1096	

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Dam Concrete (Use of Gmax 40 mm)

	Maximum aggregate 40 mm	Maximum aggregate 80 mm
Quality (strength, durability, heating properties)	It is confirmed from mixing test and thermal stress analysis that it satisfies the performance requirements of dam concrete.	**Same as left**
	Δ	○
Workability	**Applicable (Fewer past applications)** → It is confirmed from workability test that excellent applications will be possible by remodeling part (caterpillar part) of the buyback.	**Applicable (Plenty of past applications)**
	○	○
Economic efficiency	**No remodeling of existing plant necessary**	**Remodeling of existing plant necessary**
	○	X
Judgment	○	Δ

Specific Problem in Case Additional Concrete is Poured on the Downstream Side of the Original Dam Body

Dam stability

- Design with reservoir impounding condition considered
  → Kakitani's formula

Integration of the new and old dam bodies

- Confirmation of strength of the construction joints between new and old concrete

Review of thermal stress

- Review of thermal stress unique to dam enlargement project (additional concreting on the back of the original dam body)

Integration of the New and Old Dam Bodies (In-situ Shear Testing)

- Integration of the new and old dam bodies has no problem when the shear strength is estimated from the compressive strength of the original dam body. But validity of estimation of the strength of the rubble concrete from the boring core is debatable.

In-situ shear test

[Test results]

- **Shear strength:** 2.0 N/mm²
- **Shear stress of the new and old concreting joints:** 0.5 N/mm²

Integration of new and old dam bodies allowed

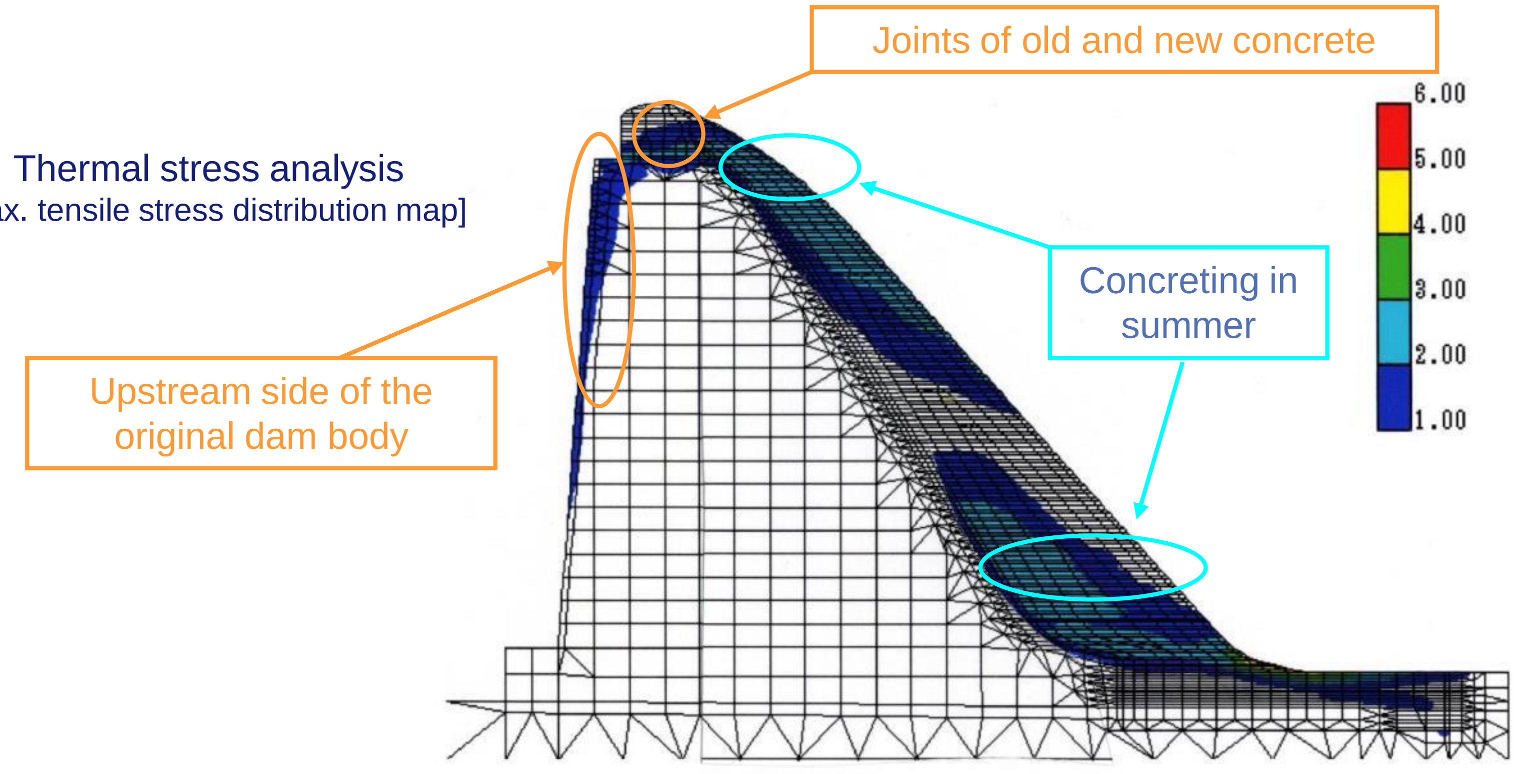
Additional actions to take:
chipping and joint bar

Review of Thermal Stress

[Problems related to thermal stress for dam enlargement project]

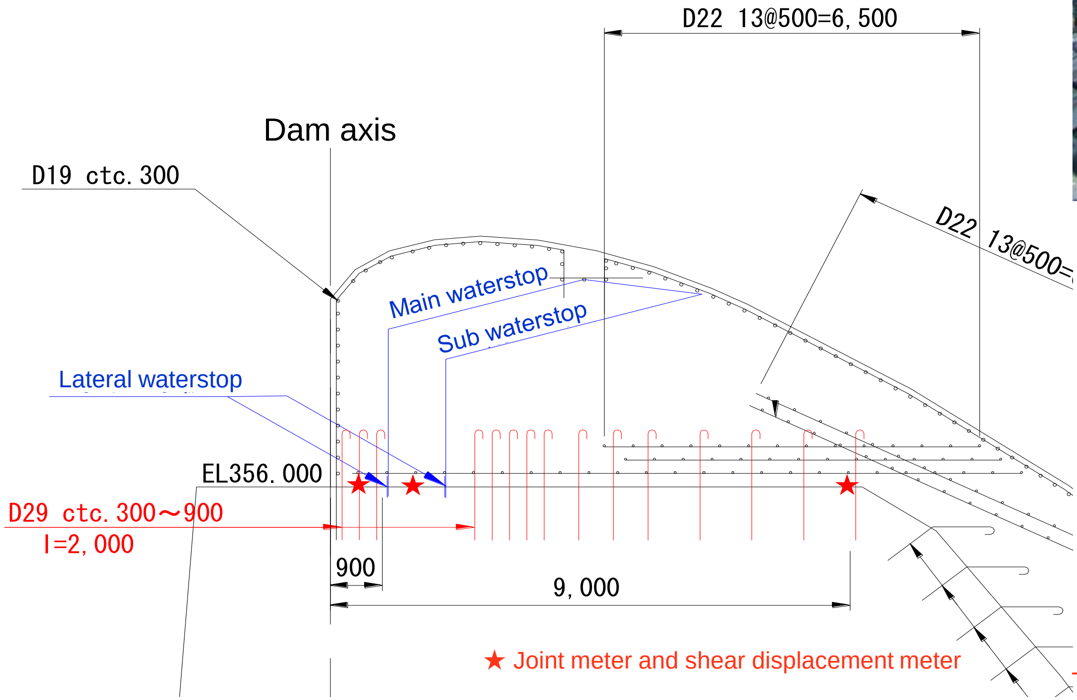
1. Reduction in thermal stress (the same measures as those for general mass concrete)
2. Measures for tensile stress on upstream side of the existing dam body
3. Review on the impact of the restricting conditions (existing dam body as a restricting condition)

Thermal stress analysis
[Max. tensile stress distribution map]



Example of Thermal Stress Measures (1) [Measure to treat local stress on construction joints of the new and old concrete]

- Large tensile stress occurs locally on the construction joints between new and old concrete at the top part (flat part) of the original dam body.
- It is potentially the most vulnerable point for the structure, and full stress measures and cut-off water measures are necessary.



- Reinforcement by rebars
- Water-stop plates in the dam axial direction

- Monitoring of behavior with buried meters
- Verification of thermal stress analysis

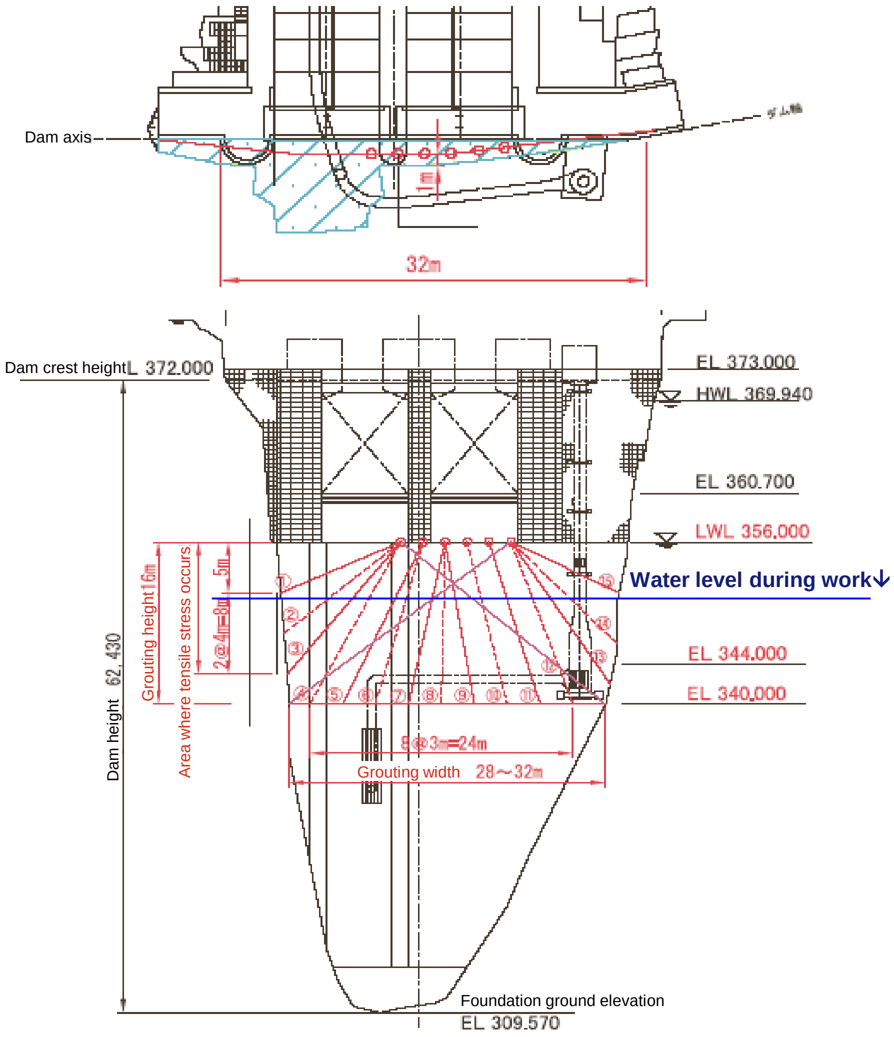
Example of Thermal Stress Measures (2) [Measures against Tensile Stress on the Upstream Side of the Existing Dam Body]

- Although thermal stress that occurs is smaller than the concrete's tensile strength, the part is in direct contact with water, and in case any crack occurs, it could lead to leakage of the dam reservoir.

- Since the work is conducted with the reservoir filled with water, it is difficult to conduct any drastic measures that fully covers the areas where tensile stress will occur.

Apply grouting to the upstream side of the existing dam body.

Plan view



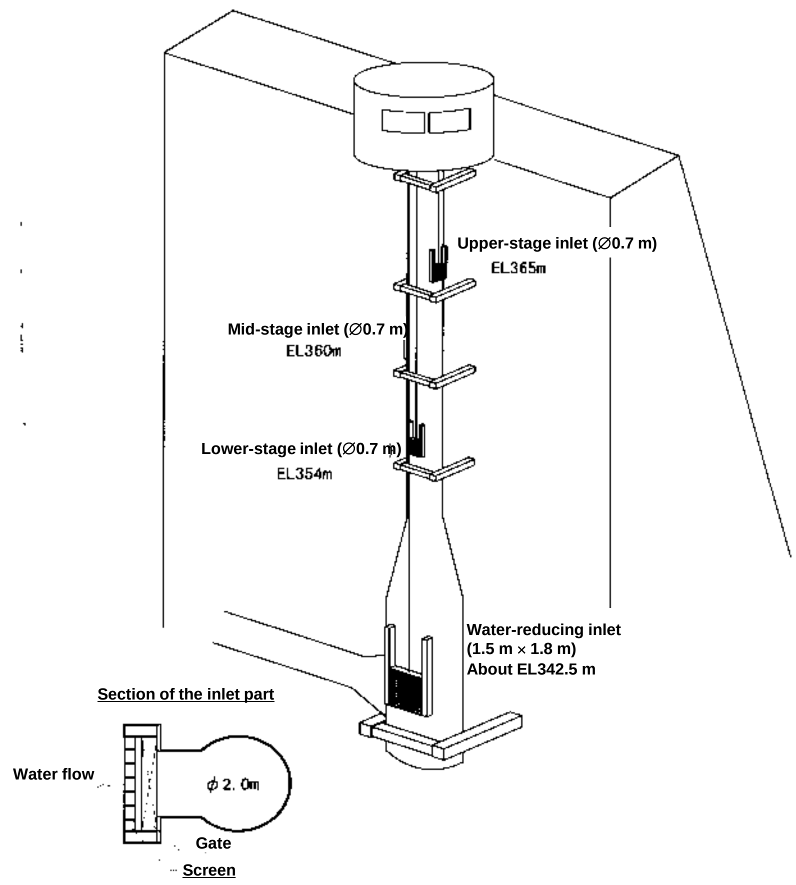
Maintenance Flow Discharge Facility

- Maintenance flow
  Apr. to Nov.: 0.687 m^3/s
  (0.57 $m^3/s/100\ km^2$)
  Dec. to Mar.: 0.360 m^3/s
  (0.30 $m^3/s/100\ km^2$)

- Considering the impact on the downstream area (reduction of water temperature because of released water), porous selective intake facility should be installed.

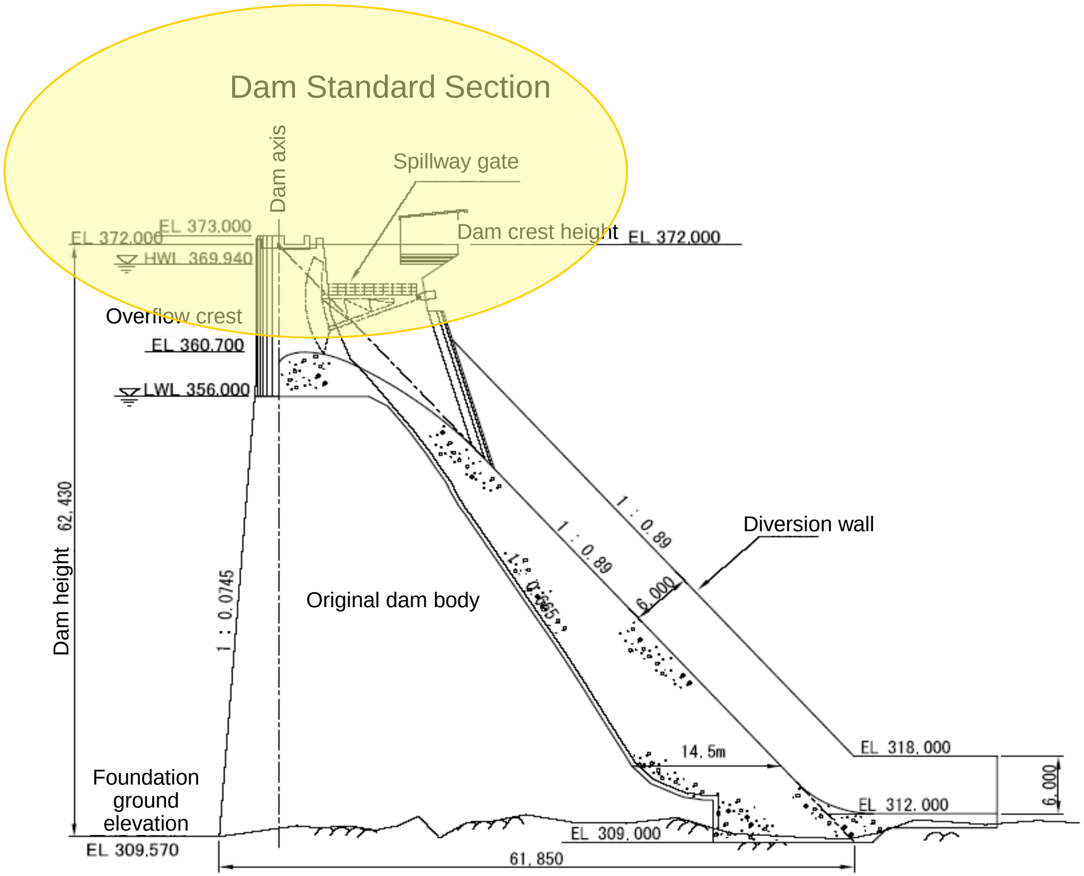
- To preserve the river environment, additional release (flashing discharge: max. 4.7 m^3/s) should be conducted using this facility.

Outline of Maintenance Flow Release Equipment

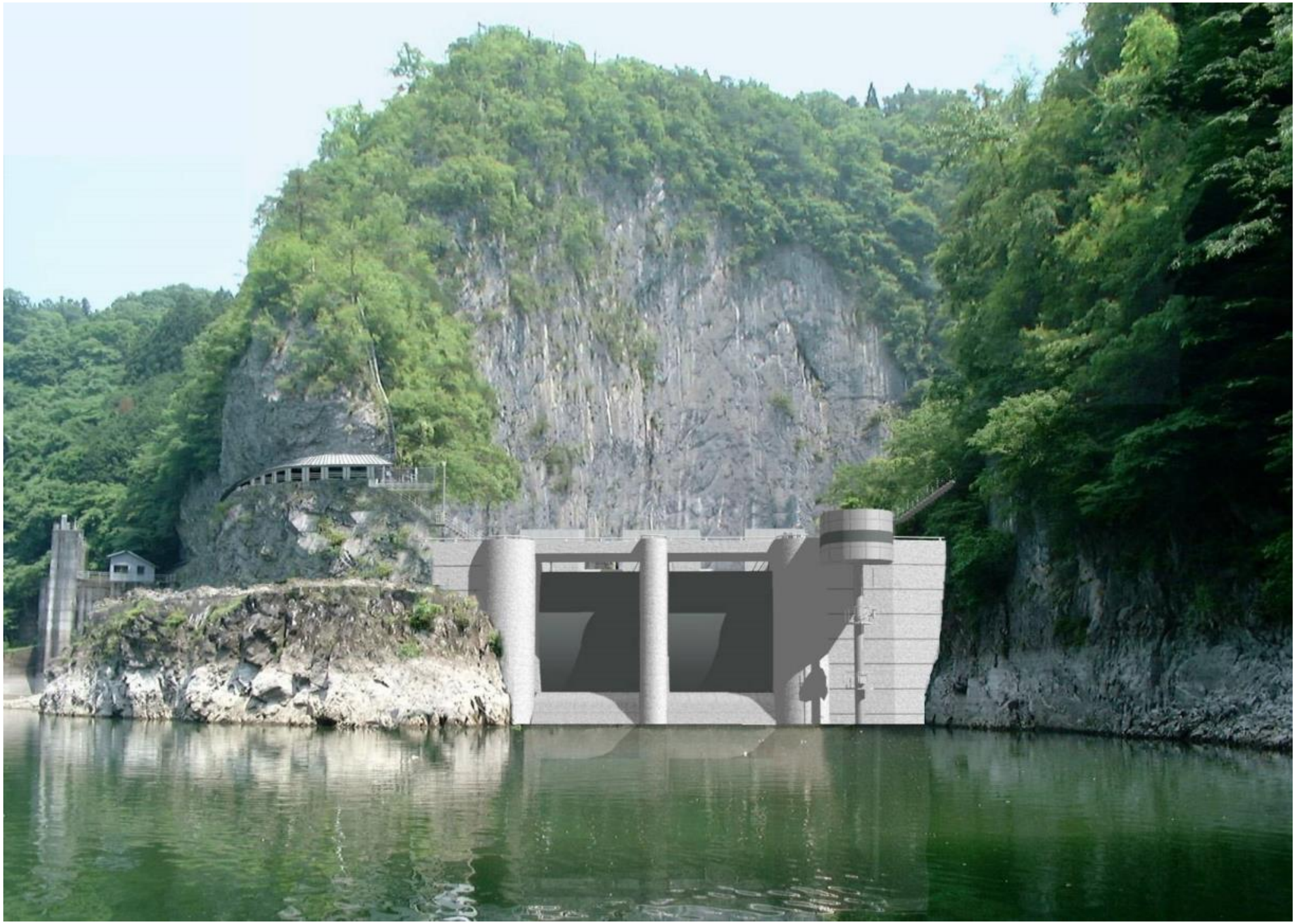


Spillway Gate

Radial gate (rear wind-up type) is adopted for the purpose of better aesthetics.



Spillway Gate (CG of Completed Gate)



[Construction] Important Points to Note for Formulation of Temporary Facility Plan

[Strict topographic conditions and environmental restrictions]

- The dam site area is characterized by extremely steep and narrow topography with limestone-based steep cliffs continuously flanking the river.
  - →No road available for access of work vehicles to the dam site nor any yard of a sufficient area
- Any change of the natural condition isn't allowed in principle.

↓

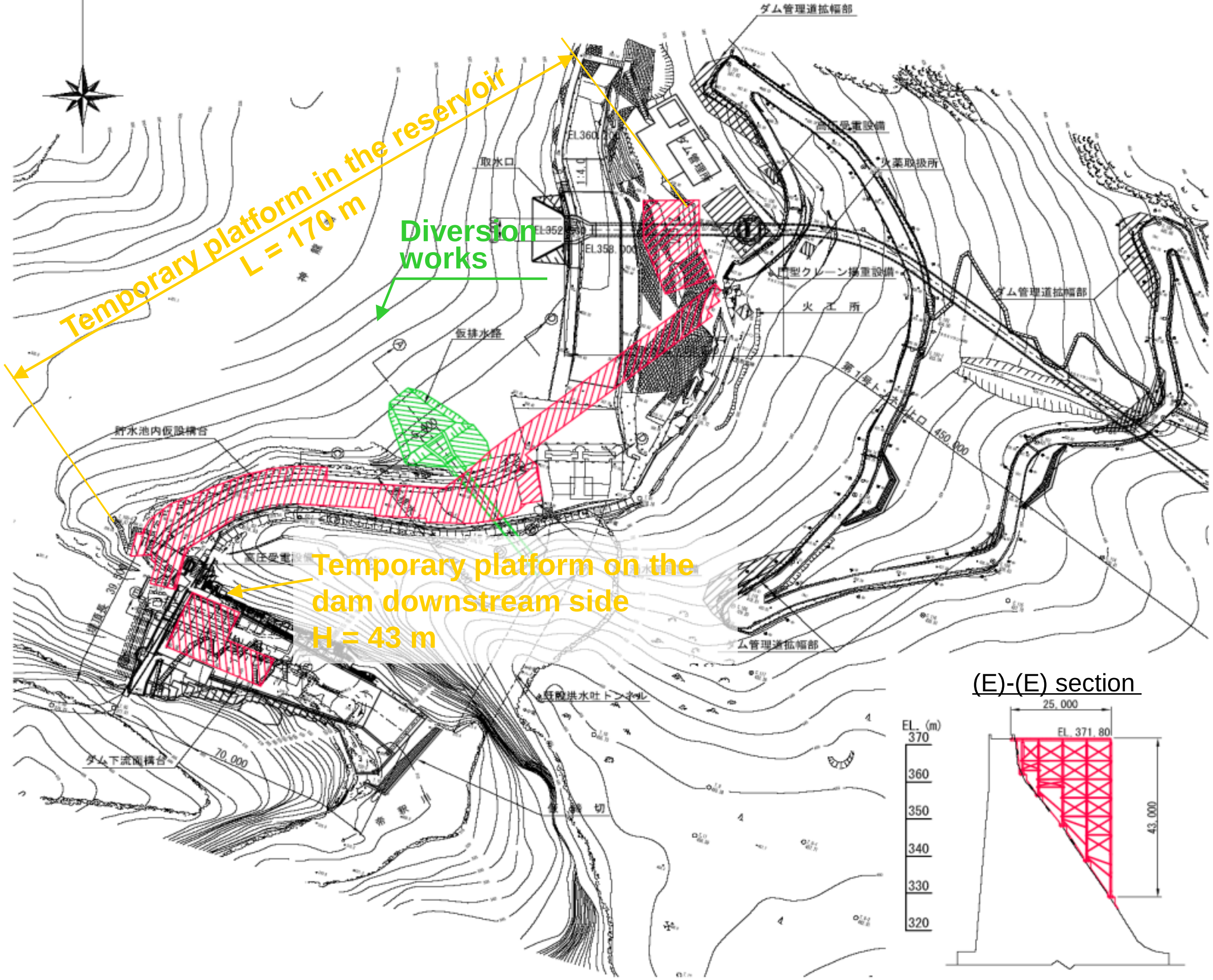
Construction using machine as in the case of ordinary dam construction work is difficult.

↓

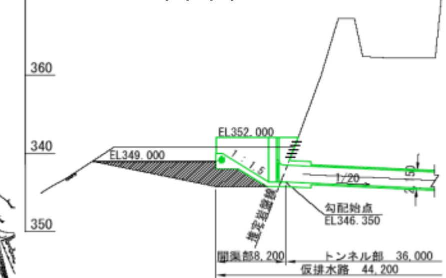
Temporary facility plan is an important factor that determines the failure or success of the work.

Plan View of the Temporary Facility

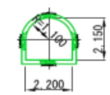
Plan View of the Temporary Facilities around the Dam



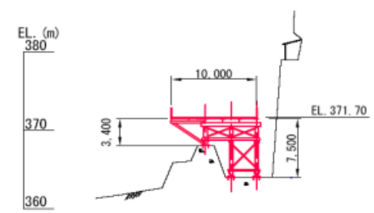
Temporary drainage canal
(A)-(A) section



(B)-(B) section



Temporary platform
(C)-(C) section (conventional method)



(E)-(E) section

(D)-(D) section (Sqc method)

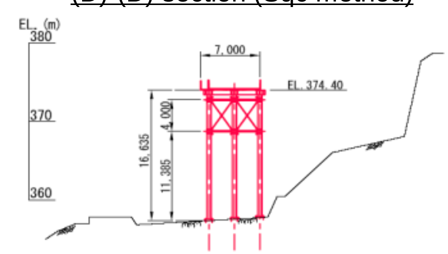
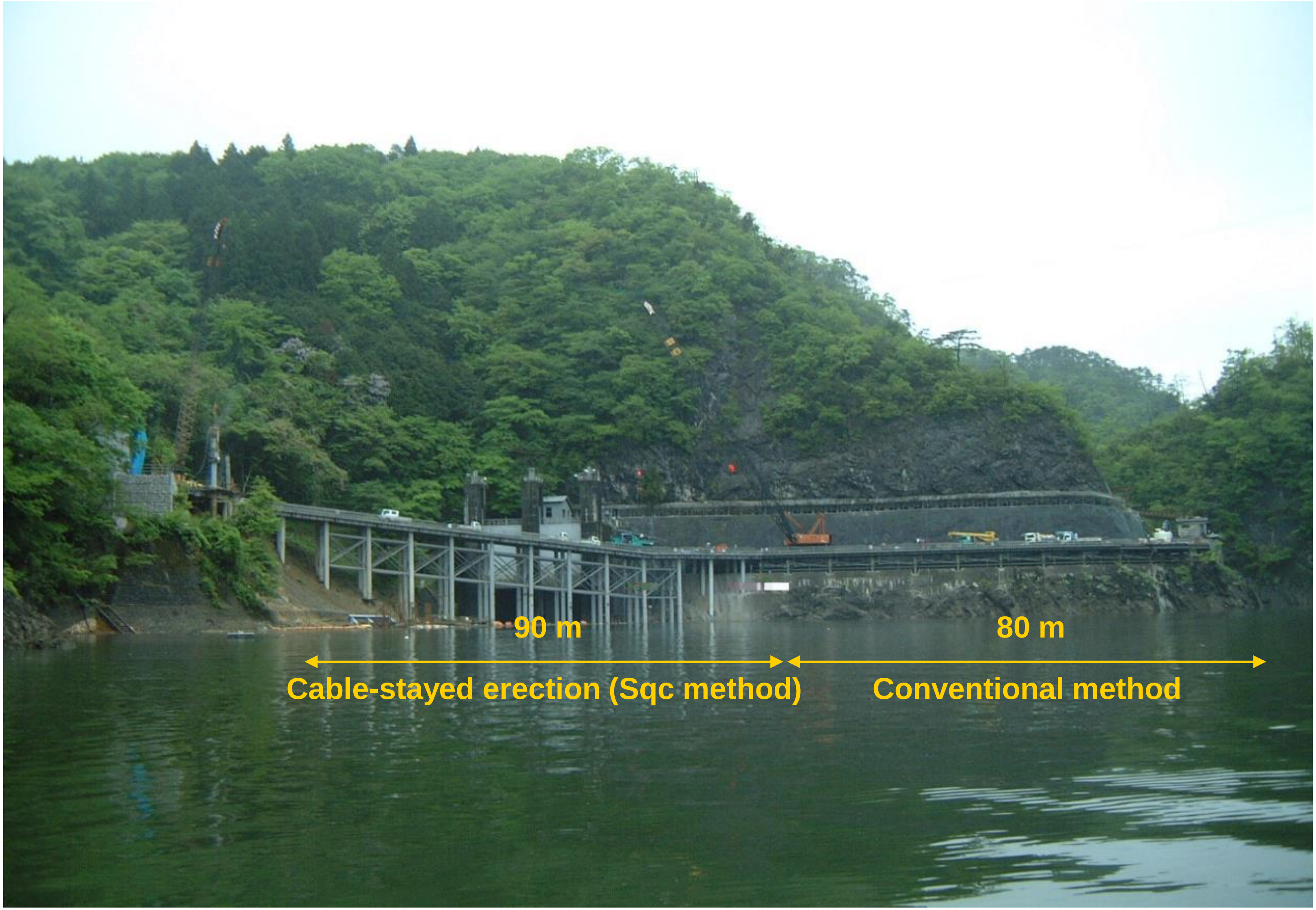


Photo Showing Temporary Facilities Around the Dam Reservoir

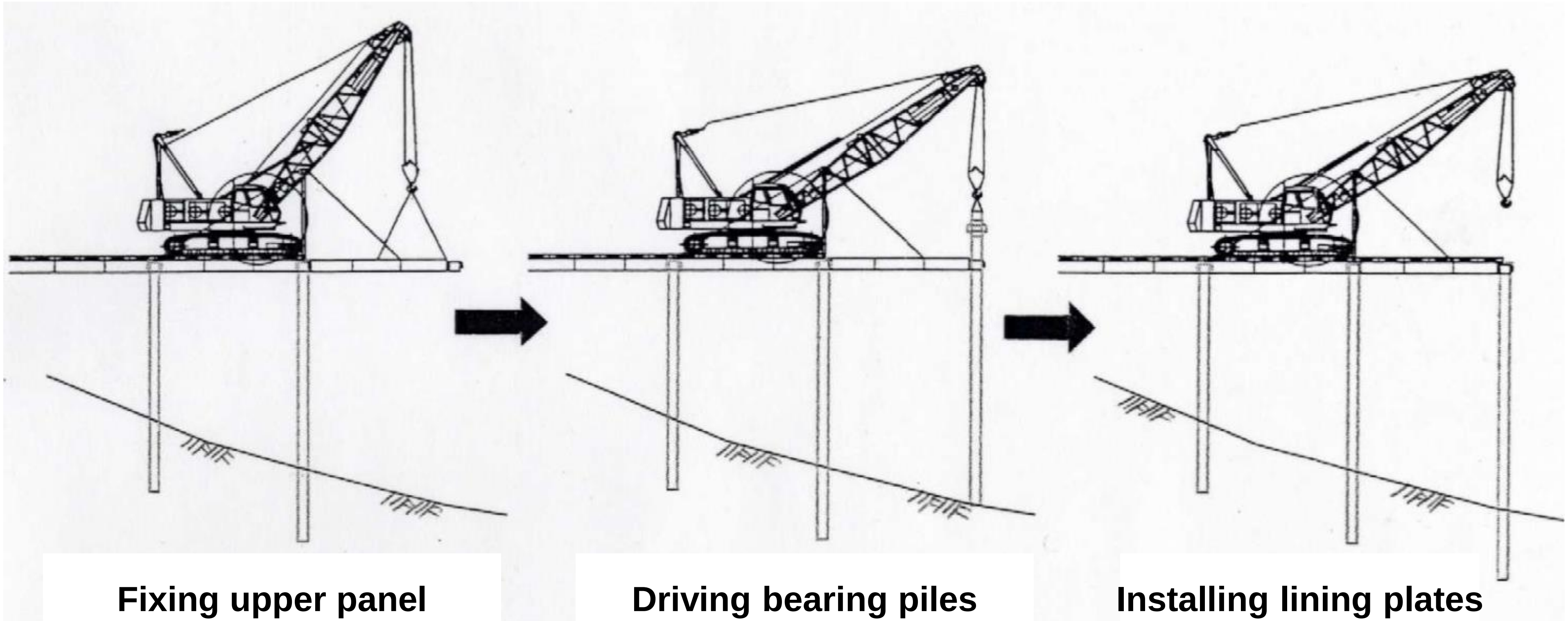
Improvement of Dam Management Road
(Road expansion of the Hairpin Curve)

Transport of 80-ton Crawler Crane

Temporary Platform in the Reservoir



Temporary Platform in the Reservoir (Cable-stayed Erection - Sqc Method)



No work at the foundation part →

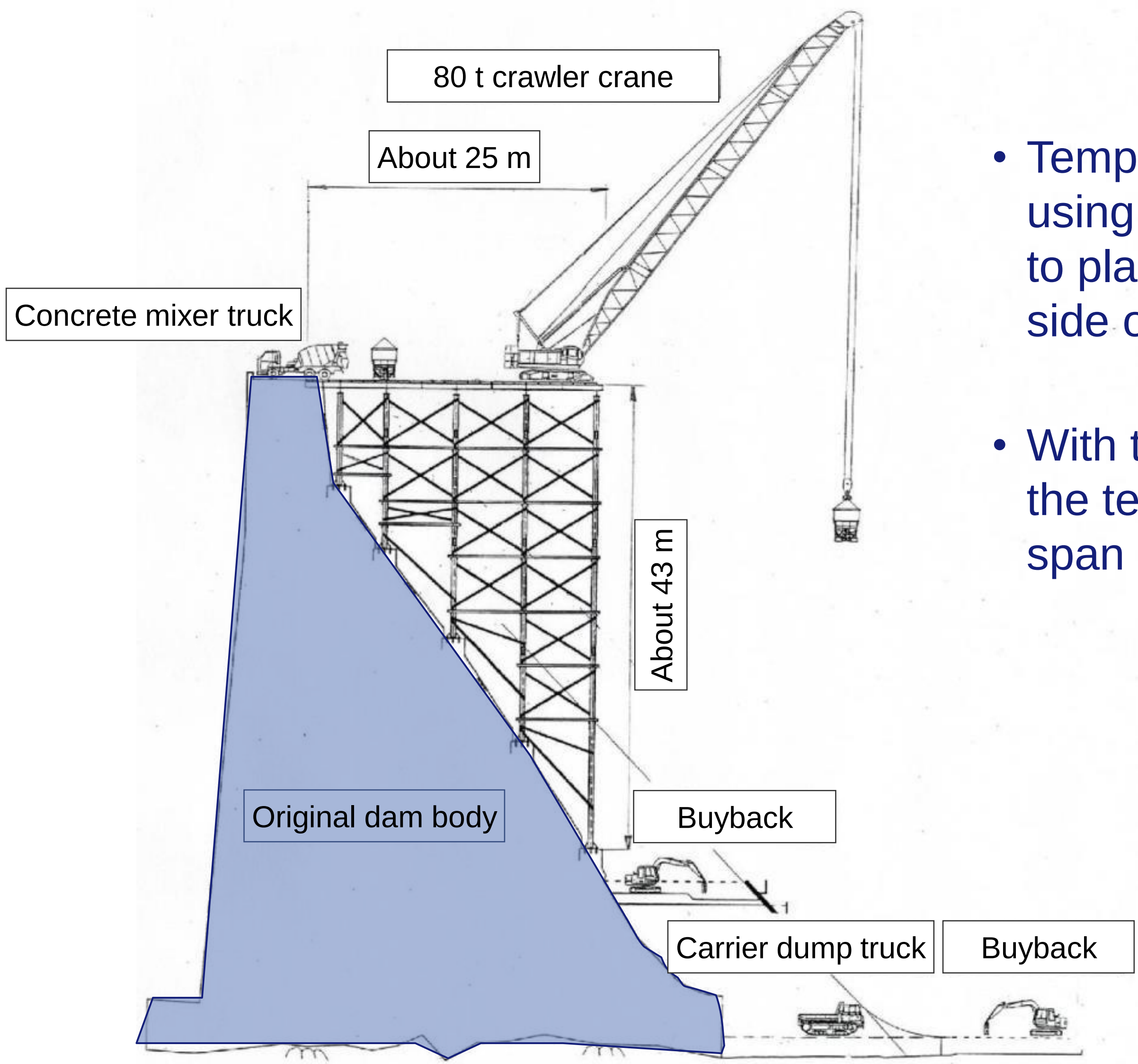
Cutting work on the slope or level adjustment work not necessary

Work will not be affected by the water level of the reservoir.

Temporary Platform in the Reservoir (Sqc Method)

Temporary Platform in the Reservoir (Conventional Method)

Temporary Platform on the Downstream Side of the Dam



- Temporary platform was constructed using the conventional method in order to place concrete on the downstream side of the dam.
- With the progress of dam concreting, the temporary platform was removed span by span.

Temporary Platform on the Downstream Side of the Dam

Temporary Platform on the Downstream Side of the Dam (Seen from Downstream Side)

Diversion Works (Design)

[Selection of the subject flow discharge]

When a concrete dam is constructed, even though water overflows during the construction work, it will not generally cause any fatal damage providing the work is conducted with the possible place of overflow properly taken into consideration. Therefore, the subject flood discharge adopted for the design of a gravity concrete dam is generally that of a flood that will occur once or twice a year.

↓

Now the subject discharge at this point is determined to be the flood discharge of once a year probability, and the appropriate flood discharge was calculated from the flood discharge data in 56 years from 1943 to 1998 .

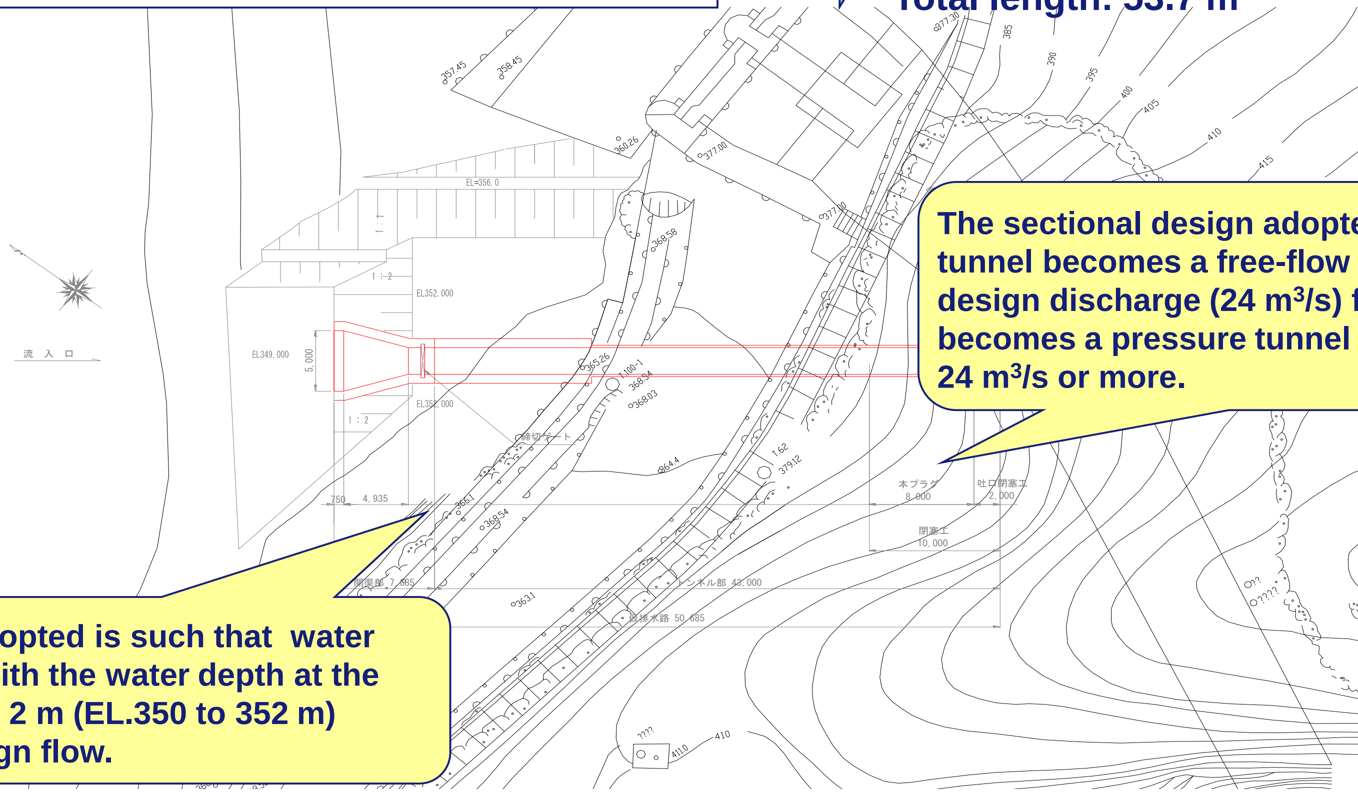
↓

Subject flow: 24 m^3/s

Diversion Works (Design)

Use the original spillway tunnel allowed excavation of a tunnel to the minimum required length, thereby realizing a cost reduction.

Non-tunnel part: 7.7 m
Tunnel part: 43.0 m
Total length: 53.7 m



The sectional design adopted is such the tunnel becomes a free-flow tunnel when the design discharge (24 m^3/s) flows down but becomes a pressure tunnel when the flow is 24 m^3/s or more.

The design adopted is such that water will overflow with the water depth at the inlet being 0 to 2 m (EL.350 to 352 m) under the design flow.

Diversion Works (Photo showing the Completed Works)

Inlet

Outlet (outlet of the original spillway)

Overhang Removal (before removal)

Appearance opening crack
(lateral to the slope)

Overhang Removal (during removal)

Overhang Removal (before and after removal)

Overhang Removal (after removal)

Riverbed Excavation

Riverbed of the downstream channel before excavation

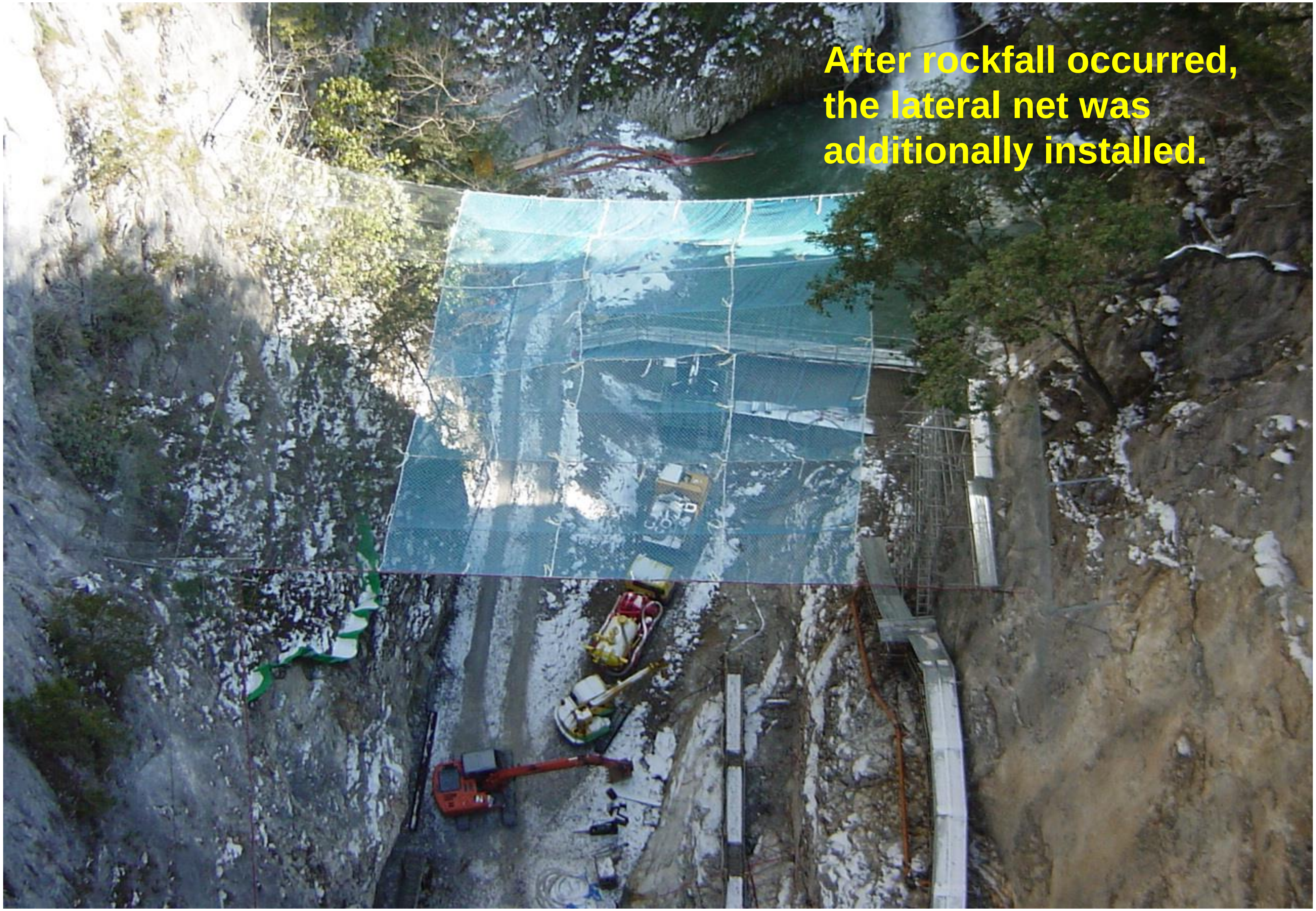
Excavation completed
(foundation ground investigation)

Excavation work

Notch on the Downstream Riverbed

Rock-fall prevention work

Rock-fall prevention work

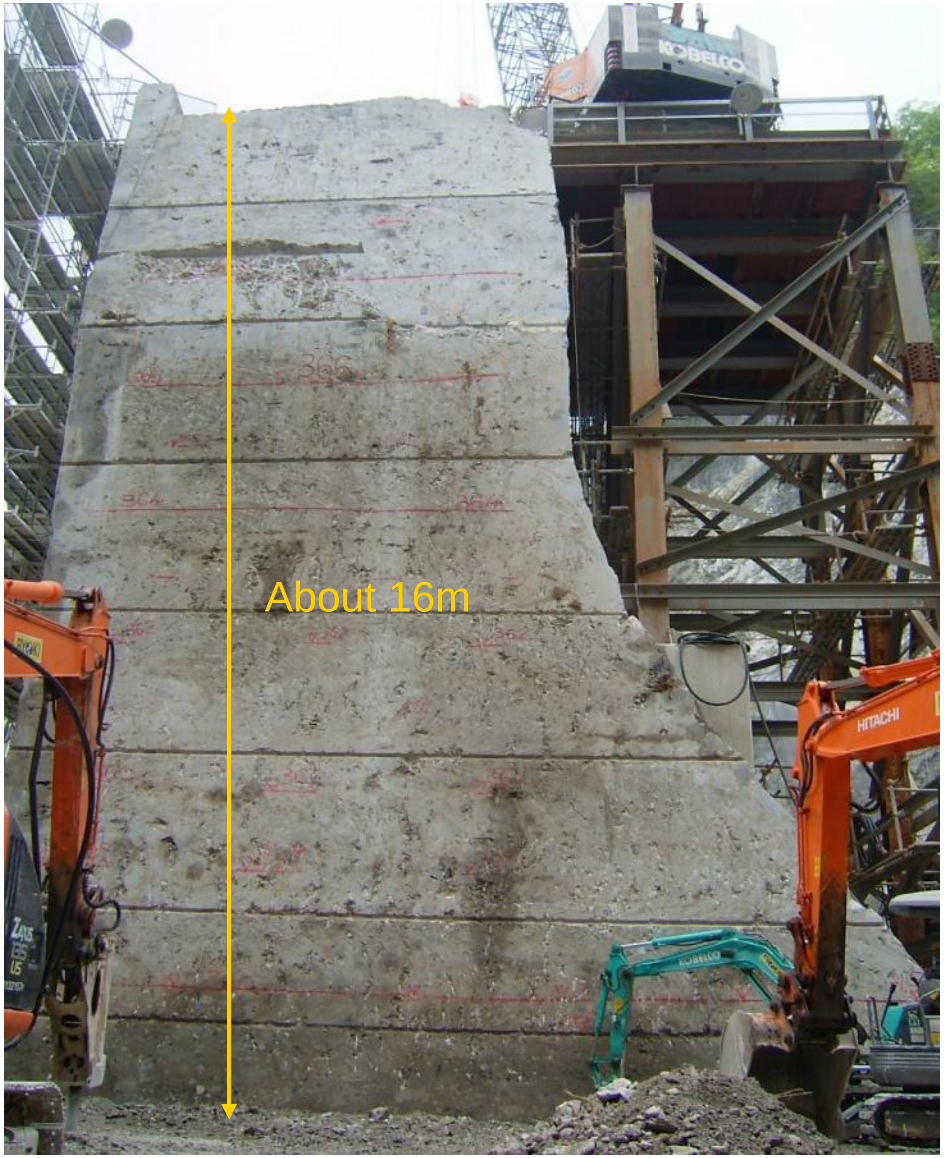


Chipping of the Original Dam Body

Removal of the Upper Part of the Original Dam Body (Intake Tower Part)

Removal of the Upper Part of the Original Dam Body (Intake Tower Part)

Removal of the Upper Part of the Original Dam Body (Right Bank)



Right-bank removal completed
(July 2005)

Dam Concrete Placement (Compaction with Mini Buyback)

Energia

Dam Concrete Placement (Compaction with Manual Vibrator)

Precooling


LN$_2$ plant was installed at the ready-mixed concrete plant.
高圧ガス
日本酸素
NIPPON SANSO
saan

Ready-mixed Concrete Transport Truck Fitted with Thermal Insulant

Dam Concrete Placement (October 2004)

Dam Concrete Placement (January 2005)

Dam Concrete Placement (March 2005)

Dam Concrete Placement (May 2005)

Removal of the upper part of the original dam body started.

Dam Concrete Placement (June 2005)

Removal of the upper part of the original dam body was simultaneously conducted.

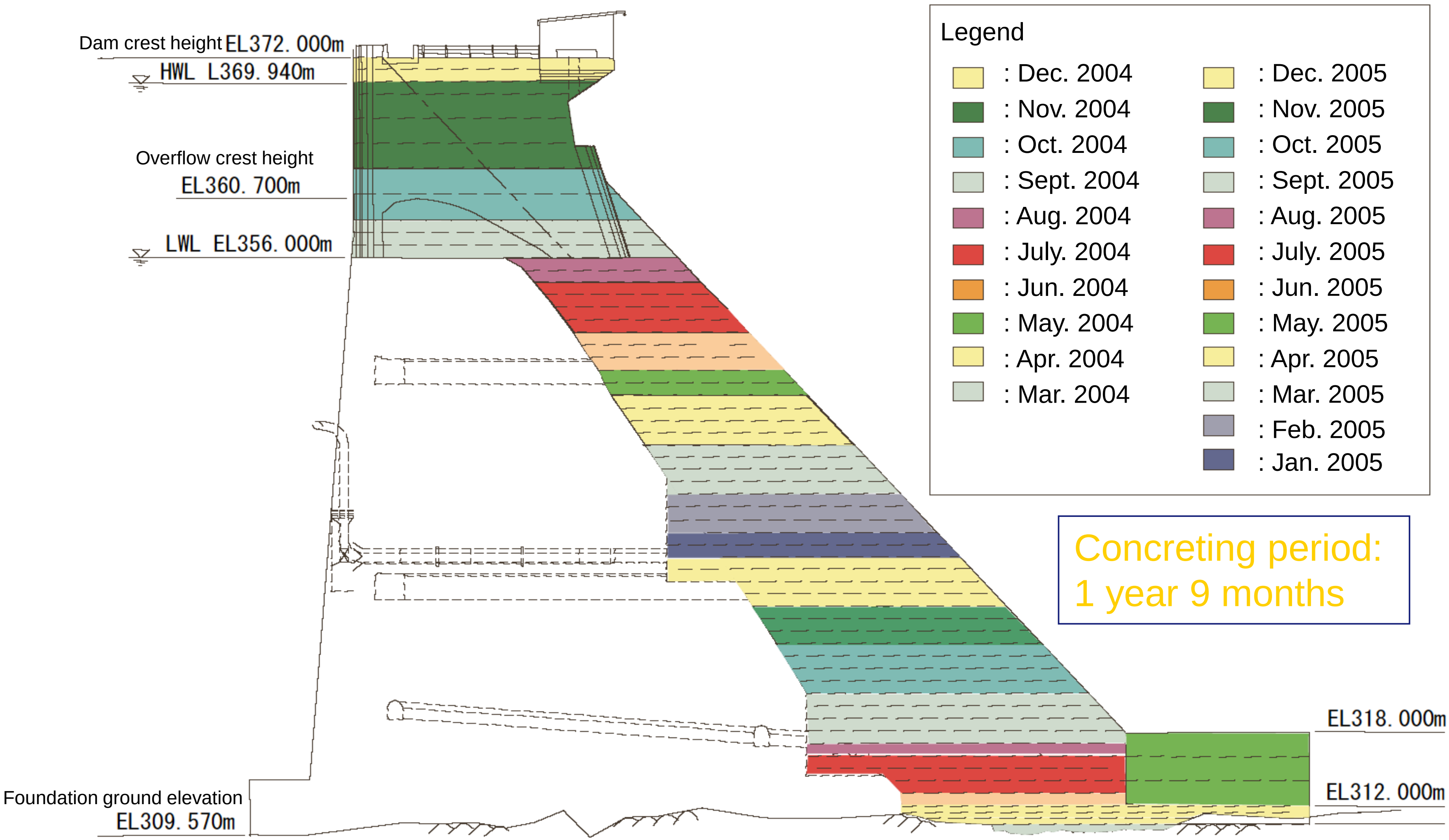
Dam Concrete Placement (August 2005)

Removal of the upper part of the original dam body was completed.

Dam Concrete Placement (October 2005)

Dam Concrete Placement (December 2005)

Dam Concreting Records



Concreting period:
1 year 9 months

Dam Construction Work (February 2006)

Spillway gate being installed

Photo showing Dam Work Completed

Photo showing Dam Work Completed

1. Overview of the Power Station Project

2. Design and Execution of Dam Renovation

3. Environmental Conservation Measures

Major Actions Taken

Action	Description
Protection of valuable fauna and flora	(1) Protection and monitoring of rare birds of pray (hawk eagle)
	(2) Moving, relocation, and monitoring of valuable fauna and flora
	(3) Enhancement of the work-related people's consciousness of protection
Landscape design	(4) Landscape design for the area around the dam
	(5) Landscape design for the area around the power station
Cyclic use of construction by-products	(6) Recycling of sludge produced from treatment of turbid water
Reduction in the natural area to modify	(7) Use of already developed or changed areas
Preservation of the river environment	(8) flashing discharge, treatment of turbid water, and water quality monitoring

Protection and Monitoring of Rare Birds of Prey (Hawk Eagle)

- Noise control measures
  - No use of dynamites in the breeding period (January to July)
  - Use of soundproof doors and sound-insulation sheets (all through the year)
- Use of appropriate lighting for the night-time work (use of sodium vapor lamps)
- Monitoring of growth and breeding by specialists
- Use of bister, a subdued color, for penstock coating (Our standard is gray).

A couple of hawk eagles

Moving, Relocation and Monitoring of Valuable Fauna and Flora

○ Valuable species confirmed in the work area

- Fauna: 5 species (*Stereophaedusa costifera, Sasakia charonda, etc.*)
- Flora: 19 species (*Buxus microphylla var. insularis*, *Anemone nikoensis*, *Adonis amurensis, etc.*)

● Valuable fauna and flora in the work-affected area should be moved and relocated before commencement of the work.

● Monitoring of the inhabitation condition by specialists

Stereophaedusa costifera

Buxus microphylla var. insularis

Enhancement of the Work-related People's Consciousness of Protection

- Distribution of a leaflet describing the valuable fauna and flora to all work-related people.
- Holding of field workshops for work-related people.

To the Work-related People (Regarding Protection of Valuable Fauna and Flora)

The Chugoku Electric Power Co., Ltd.
Shin-Taishakugawa Power Station Construction Office

Leaflet (notebook size)

Field workshop

Landscape Design of the Area around the Dam (1/2)

- Dam design with the harmony with the surrounding landscape (continuous presence of limestone cliffs) taken into consideration
  - ○ Instructions of specialists
  - ○ Shape, size, and coloring of structures; and the color of the gate

Expected as-built photo (CG) of the dam and its surrounding

Landscape Design of the Area around the Dam (2/2)

- Subdued color (gray) is also entirely used for the temporary facilities to ensure harmony with the surrounding landscape.

Temporary platform in the reservoir

Recycling of Sludge Produced from Treatment of Turbid Water (Cycling Use of Construction By-products)

- Sludge generated from turbid water treatment is mixed with coal ash for quality improvement, and the mixture is recycled as construction materials for the project site.

Dewatered cakes

Improved soil

Use of Already Changed Area (Reduction in the Natural Area to Modify)

- The dam management road for the existing dam is reused, with its road width (3.5 m) almost unchanged, for a construction road for vehicles entering to the dam site (which is located in one of the government-designated scenic places).
- Various pieces of construction equipment are placed on the already modified areas.

Dam management road (80-ton crane driving on the road)

Flashing discharge, treatment of turbid water, and water quality monitoring (Preservation of the River Environment)

- Flashing discharge is conducted to improve the downstream river environment of the dam.
  - Changing the normal release moves sand and sediments in the river water to prevent adhesion or deposition of sludge.
- Treatment of turbid drainage water ⇒ Sludge after treatment is recycled.
- Monitoring of river water quality

Flashing release of water

Closing Remarks

- The number of dam redevelopment projects is predicted to increase for the purpose of elongating the dam service life or making effective use of dams considering the ongoing aging of dams, depletion of new dam sites, and increasing difficulty in finding dam sites.

- The redevelopment project of the Taishakugawa Dam covers the majority of technical tasks related to redevelopment of concrete dams, and it is understood to be the model case for future concrete dam redevelopment as a case of systematization and compilation of all those techniques.

Thank you for your attention.