Advanced Technologies to Upgrade Dams under Operation

can reduce
COSTs,
CONSTRUCTION PERIODs,
ENVIRONMENTAL IMPACTs.

Tsuruda Dam has been operated since 1966
The upgrading project started in 2006

Japan Commission on Large Dams

Japan Dam Foundation

Japan Dam Engineering Center

Japan Association of Dam & Weir Equipment Engineering

Water resources Environment Center

Japan Water Agency

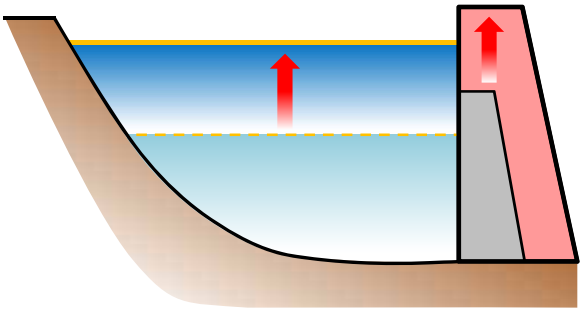
Public Work Research Institute

Water and Disaster Management Bureau
Ministry of Land, Infrastructure, Transport and Tourism

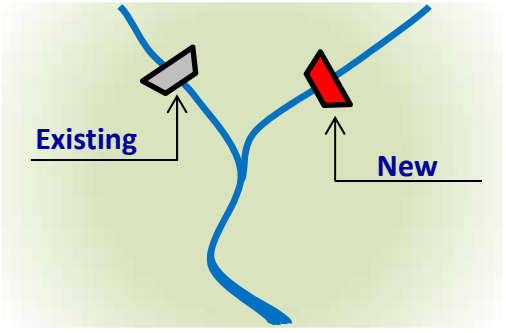
MLIT executes comprehensive water management

Planning	Decides long term visions and mid term plans for flood control and water resource development.
Coordinating	Coordinates parties which are stakeholders in water.
Implementing	Acts as the headquarter for river improvement projects and dam projects including dam upgrading.
Accumulating	Accumulates technical knowledge related to river projects in cooperation with the NILIM and PWRI and other R&D institutions.

Image of upgrading dam under operation



Upgrading the dam (ongoing)



Building a new dam (reconstruction)

SOCIAL IMPACTs

Almost no impact on the local society	Necessity to reconstruct the local society

~~Substitute roads& negotiating reconstruction~~ → Substitute roads& Negotiating reconstruction

Upgrading dam is ***more reasonable, short-term, and ecological work*** than a new dam building.

~~Environmental assessment~~ → Environmental assessment

ENVIRONMENTAL IMPACTs

Almost no impact on animals and plants	Necessity to mitigate impacts on animals and plants

Technologies to upgrade dams under operation

1. Technologies to increase reservoir volume P3

1-1 Raising the dam body
1-2 Constructing a new dam just downstream from the operating dam without stream diversion
1-3 Under water structural engineering work to construct in deep reservoir

2. Technologies to increase discharge capacity P5

2-1 Constructing additional crest gates
2-2 Drilling the existing dam body from downstream
2-3 Constructing new spillways
2-4 Upgrading existing spillways

3. Technologies to improve structural stability P7

3-1 Improving an existing dam's structural stability to resist earthquakes damage
3-2 Controlling seepage through dam bodies and/or their foundations
3-3 Improving structural stability of downstream
3-4 Inspecting structural stability to resist catastrophic earthquakes

4. Technologies to improve operation P9

4-1 Maximizing its functions through coordination with several other dams
4-2 Implementing flexible operation well timed with the flood discharge
4-3 Converting to a new system while continuing operation
4-4 Constructing or upgrading power plants

5. Technologies to control sediment P11

5-1 Controlling sediment by bypass tunnels
5-2 Excavating and transporting sediment
5-3 Constructing a check dam to control sediment
5-4 Combining several sediment removal methods

6. Technologies to improve environments P13

6-1 Adopting selective water intake facilities
6-2 Bypassing fresh water directly from the upstream to the downstream river
6-3 Adding new aerators
6-4 Adding facilities such as fish ways to conserve the ecosystem

1. Technologies to increase reservoir volume

1-1 Raising the dam body

Increasing reservoir volume to improve flood control and/or power generation.

・New Katsurazawa Dam in Hokkaido Pref. (Fig.1-1a)
・Kasabori Dam in Niigata Pref.(Fig.1-1b) etc.

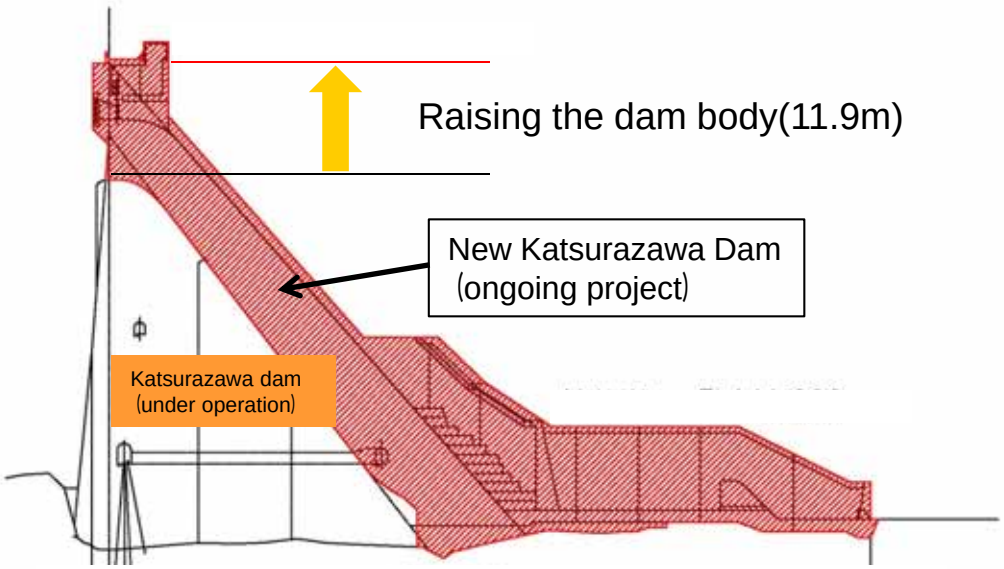


Fig.1-1a New Katsurazawa Dam (major raising)

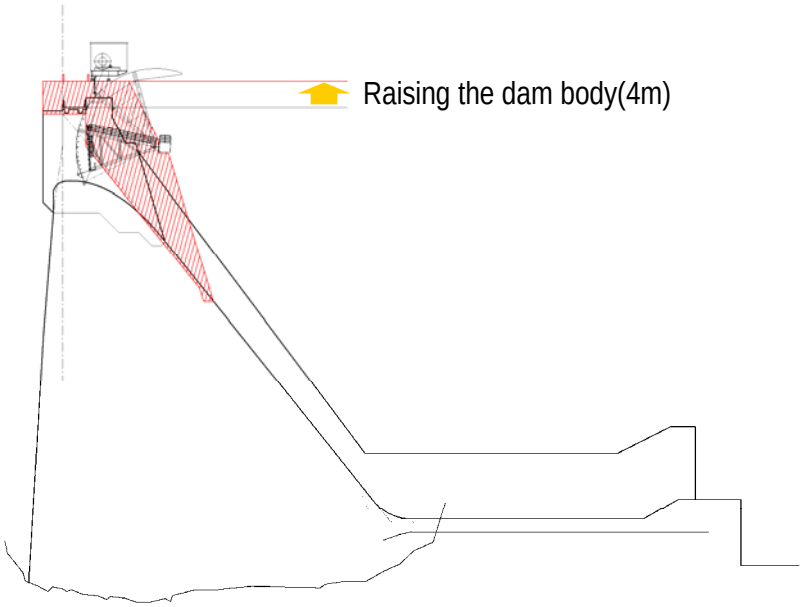
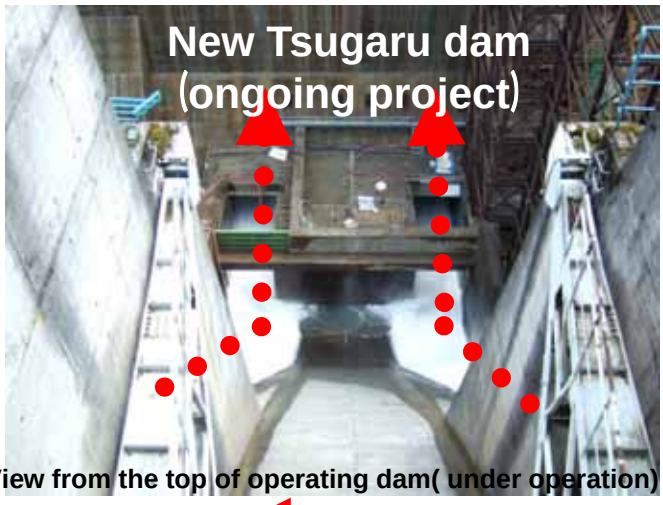


Fig.1-1b Kasabori Dam (minor raising)

1-2 Constructing a new dam just downstream from the operating dam without stream diversion

Continuing to operate the existing dam during the upgrading project.

・Tsugaru Dam in Aomori Pref. (Fig.1-2)
・Yubarishyparo Dam in Hokkaido Pref. etc.



View from the top of operating dam(under operation)

Fig.1-2 Tsugaru Dam

Flowing water

1-3 Under water structural engineering work to construct in deep reservoir

Converting a part of the active storage capacity into capacity for another pressing purpose without restricting operational functions of the existing dam.

・Tsuruda Dam in Kagoshima Pref. (Fig.1-3)
・New Katsurazawa Dam in Hokkaido Pref. etc.

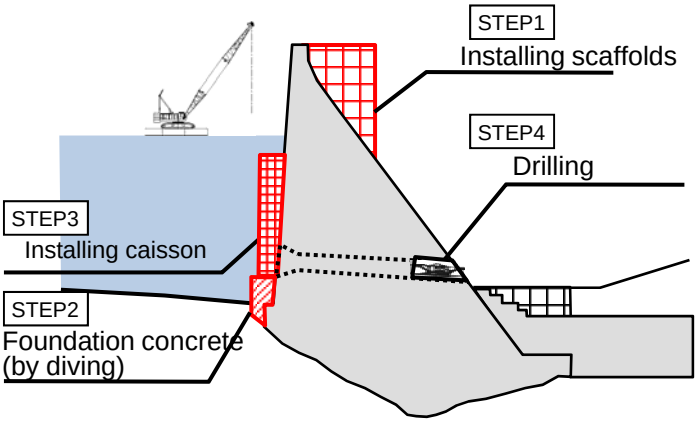


Fig.1-3 Tsuruda Dam

2. Technologies to increase discharge capacity

2-1 Constructing additional crest gates

Increasing discharge capacity to operate the dam more effectively.

・Nagayasuguchi Dam in Tokushima Pref.(Fig.2-1)
・Hori Dam in Miyazaki Pref. etc.

Fig.2-1 Nagayasuguchi Dam

2-2 Drilling the existing dam body from downstream

Increasing discharge capacity to operate the dam more effectively.

・Tsuruda Dam in Kagoshima Pref.(Fig.2-2)
・Tase Dam in Iwate Pref. etc.

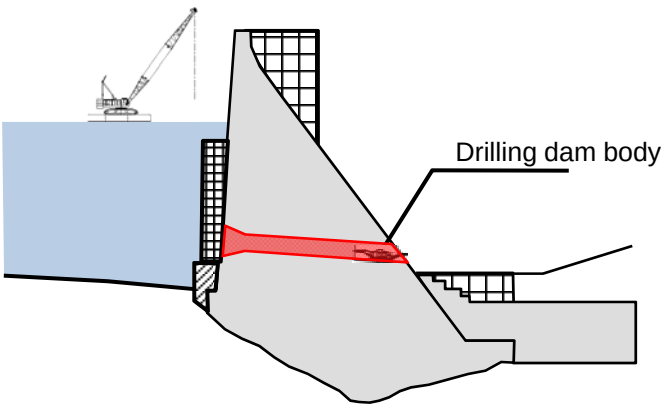


Photo taken at other dam

Fig.2-2 Tsuruda Dam

2-3 Constructing new spillways

Increasing discharge capacity to operate the dam more effectively without remodeling the dam body.

・Kanogawa Dam in Ehime Pref.(Fig.2-3)
・ Amagase Dam in Kyoto Pref. etc.

Image of completed construction

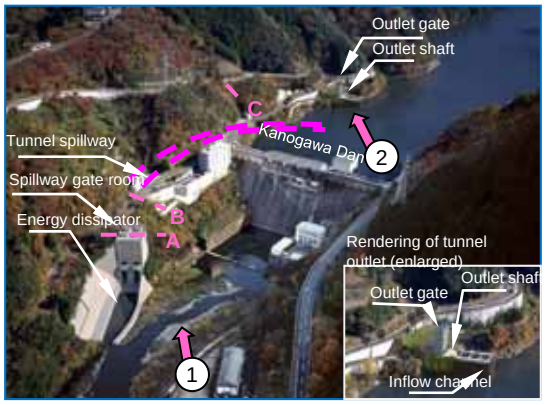


Fig.2-3 Kanogawa Dam

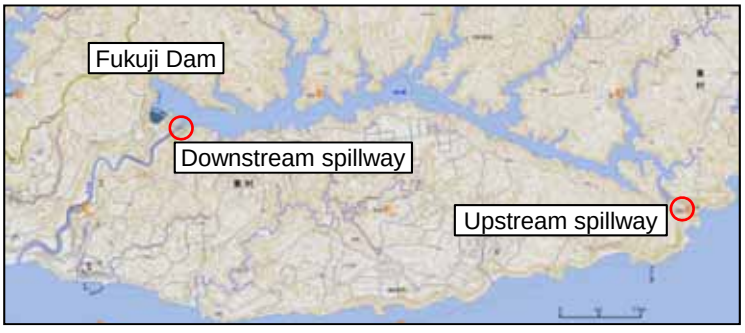
2-4 Upgrading existing spillways

Increasing discharge capacity to operate the dam more effectively without remodeling the dam body.

・Fukuji Dam in Okinawa Pref.(Fig.2-4)
・Sabaishigawa Dam in Niigata Pref. etc.

(1)Before building downstream spillway
(Regular and emergency use)

(2) After building downstream spillway
(Regular and emergency use)



(1) Before building upstream spillway
(Emergency use)

(2) After building upstream spillway
(Regular and emergency use)

Fig.2-4 Fukuji Dam

3. Technologies to improve structural stability

3-1 Improving an existing dam's structural stability to resist earthquake damage

Simultaneously improving seismic performance and adding flood control or other functions to an existing dam.

・Sayamaike Dam in Osaka Pref.(Fig.3-1)
・ Hongochi-Teibu Dam in Nagasaki Pref. etc.

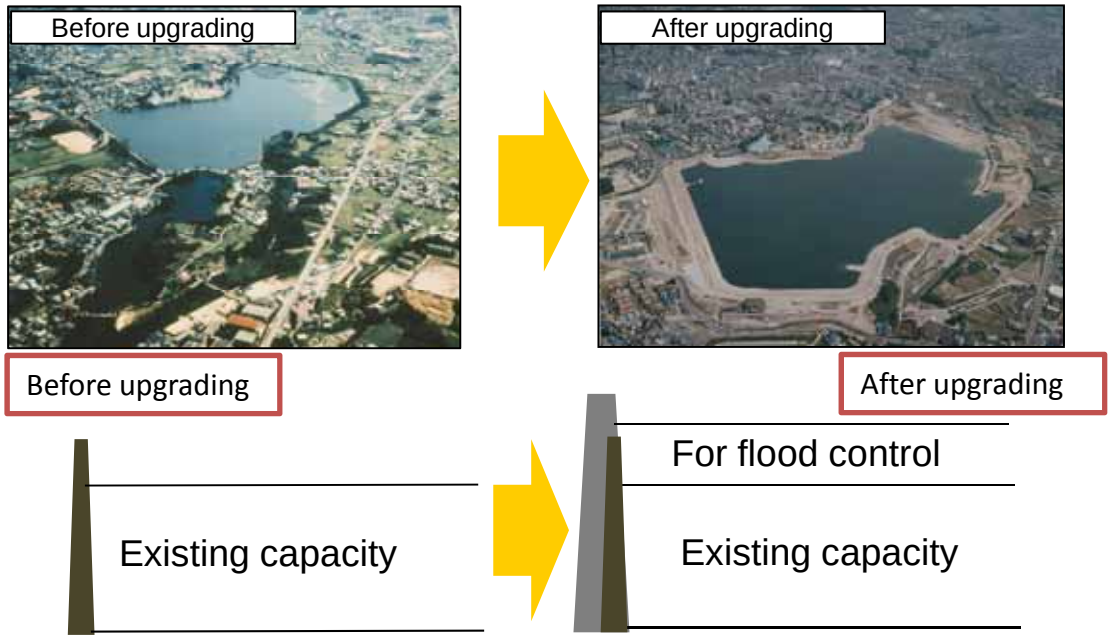
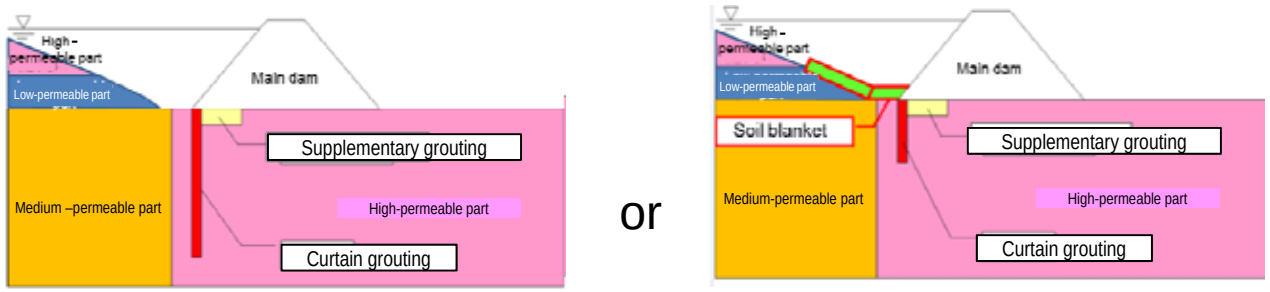


Fig.3-1 Sayamaike Dam

3-2 Controlling seepage through dam bodies and/or their foundations

Choosing the appropriate combination of countermeasures for seepage control from among many options within a limited budget .

・Okukubi Dam in Okinawa Pref.(Fig.3-2)
・Chubetsu Dam in Hokkaido Pref. etc.



etc

Fig.3-2 Okukubi Dam

3-3 Improving structural stability of downstream

Reinforcing the energy dissipator to improve structural stability of downstream under sequent operation.

・Tsuruda Dam in Kagoshima Pref.(Fig.3-3)
・Nagayasuguchi Dam in Tokushima Pref. etc.

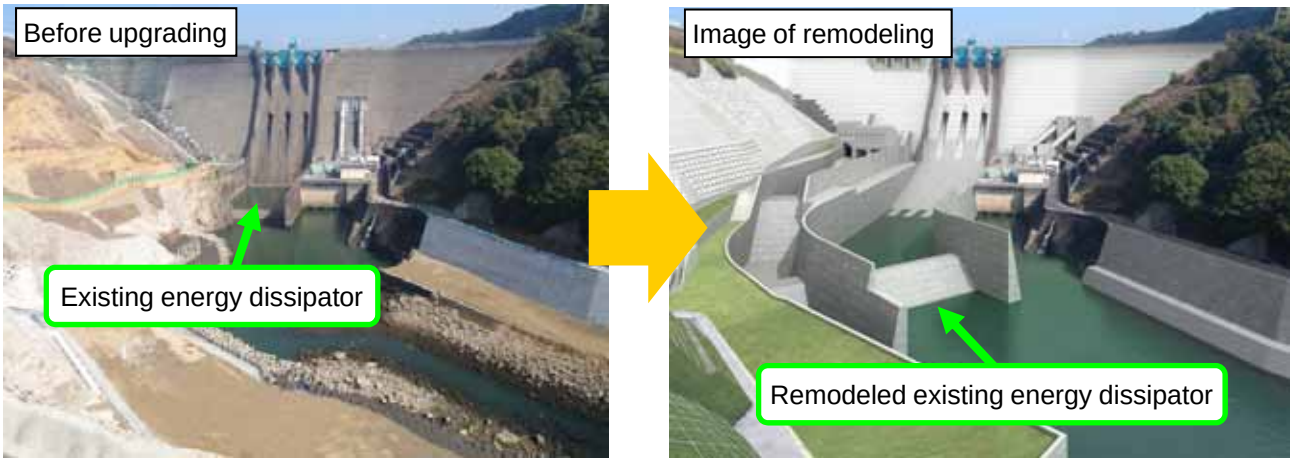


Fig.3-3 Tsuruda Dam

3-4 Inspecting structural stability to resist catastrophic earthquakes

Ensuring good seismic performance of a new or existing dams(Fig.3-4).

Design (Level 1)

<u>Seismic design standard based on the seismic coefficient method to prepare to resist the design seismic force(Level 1)</u>

- Seismic design for seismic force according to the following
  -dam type(concrete gravity, concrete arch, embankment dam)
  -area classification with earthquake motion records

Check (Level 2)

<u>Guidelines for Seismic Performances Evaluation of a Dam to resist large earthquakes over the standard design level(Level 2)</u>

Required to satisfy the following two seismic performances despite damage at the time of Level 2 earthquake motion:

(1) The water storage function must be retained

(2) Damage must remain recoverable

Fig.3-4 Seismic Design Standard and Seismic Performance Guidelines

4. Technologies to improve operation

4-1 Maximizing its functions through coordination with several other dams

Carrying out integrated operation and using water more efficiently.

- Shorenji, Hinachi and Murou Dams in the Yodo river system(Fig.4-1)
- Ikari and Kawaji Dams in the Tone river system. etc.

① Collection of information

② Supply of information

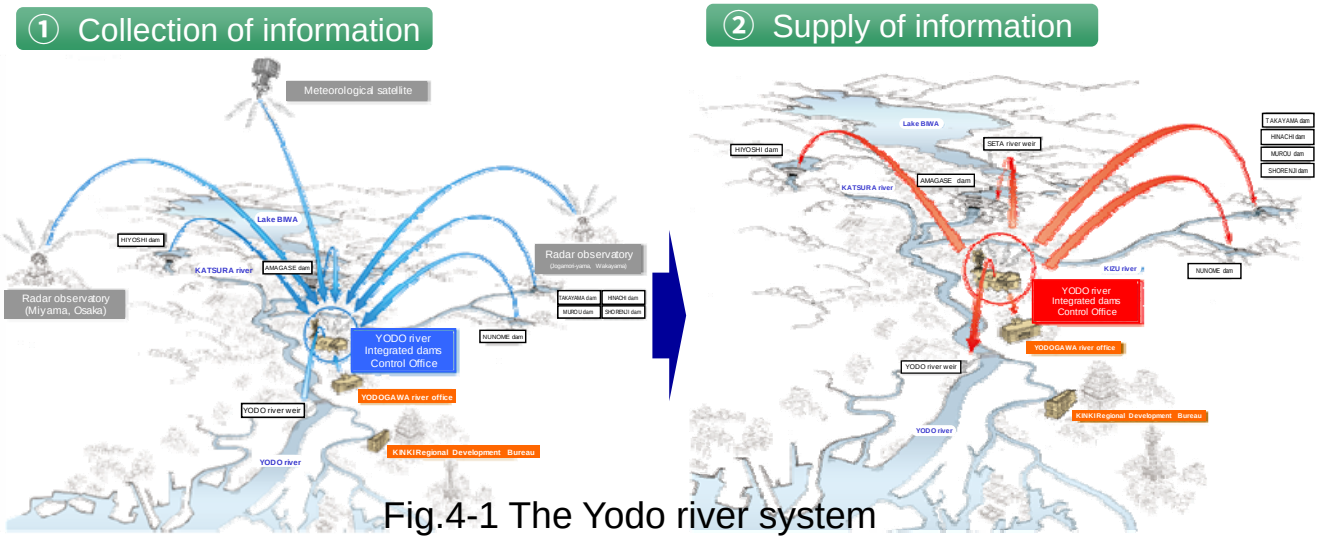


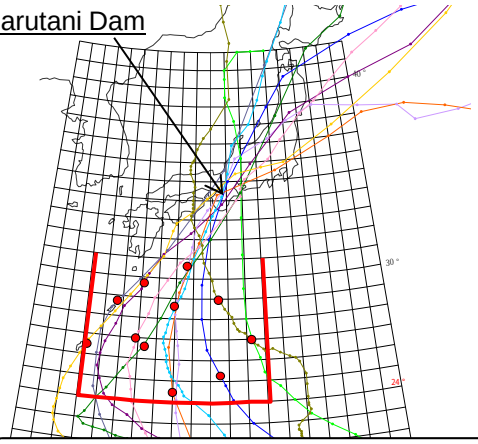
Fig.4-1 The Yodo river system

4-2 Implementing flexible operation well timed with flood discharges

Controlling floods more efficiently based on real time rainfall information collected from radar systems.

- Sarutani Dam in Nara Pref.(Fig.4-2)
- Miharu Dam in Fukushima Pref. etc.

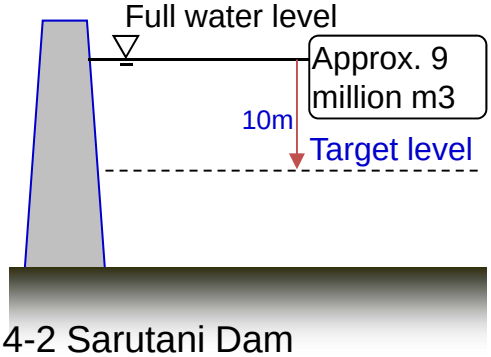
Sarutani Dam



Drawdown criteria

- Typhoon location
- Predicted rainfall
- Typhoon path

If all criteria are applicable



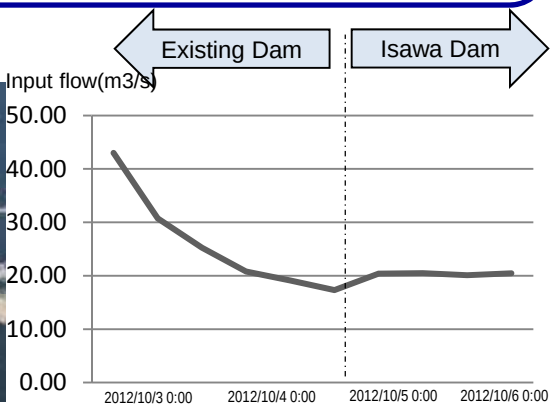
●: Center position (recorded) of a typhoon 24 hours before inflow reaches the flood discharge of 1,000 m^3/s

Fig.4-2 Sarutani Dam

4-3 Converting to a new system while continuing operation

Gathering data as the dam continues operating.

・Isawa Dam in Iwate Pref.(Fig.4-3)
・Uchinomi Dam in Kagawa Pref. etc.



Gathering data on a continuously operating dam

Fig.4-3 Isawa Dam

4-4 Constructing or upgrading power plants

Installing power plants under heavy humid conditions.

・Murou Dam in Nara Pref.(Fig.4-4)
・Terayama Dam in Tochigi Pref. etc.

Fig.4-4 Murou Dam

5. Technologies to control sediment

5-1 Controlling sediment by bypass tunnels

Ensuring life-extension and keeping the river bed stable.

- Koshibu Dam in Nagano Pref.(Fig.5-1)
- Miwa Dam in Nagano Pref. etc.

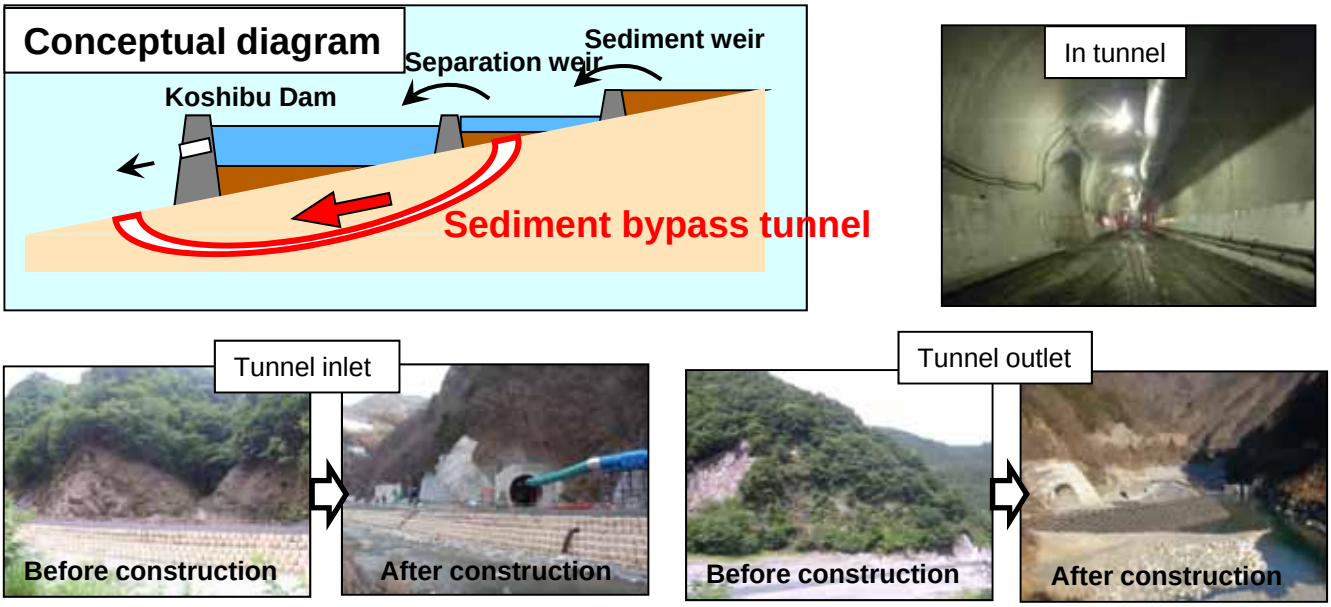


Fig.5-1 Koshibu Dam

5-2 Excavating and transporting sediment

Utilizing sediment as concrete material.

- Shichikashuku dam in Miyagi Pref.(Fig.5-2)
- Yokoyama dam in Gifu Pref. etc.

Fig.5-2 Shichikashuku Dam

5-3 Constructing a check dam to control sediment

Ensuring life-extension.

- Yuda Dam in Iwate Pref.(Fig.5-3)
- Miharu Dam in Fukushima Pref. etc.

Fig.5-3 Yuda Dam

5-4 Combining several sediment removal methods

Choosing the appropriate combination of countermeasures from among many options within a limited budget.

- Miwa Dam in Nagano Pref.(Fig.5-4)
- Sakuma Dam in Shizuoka Pref. etc.

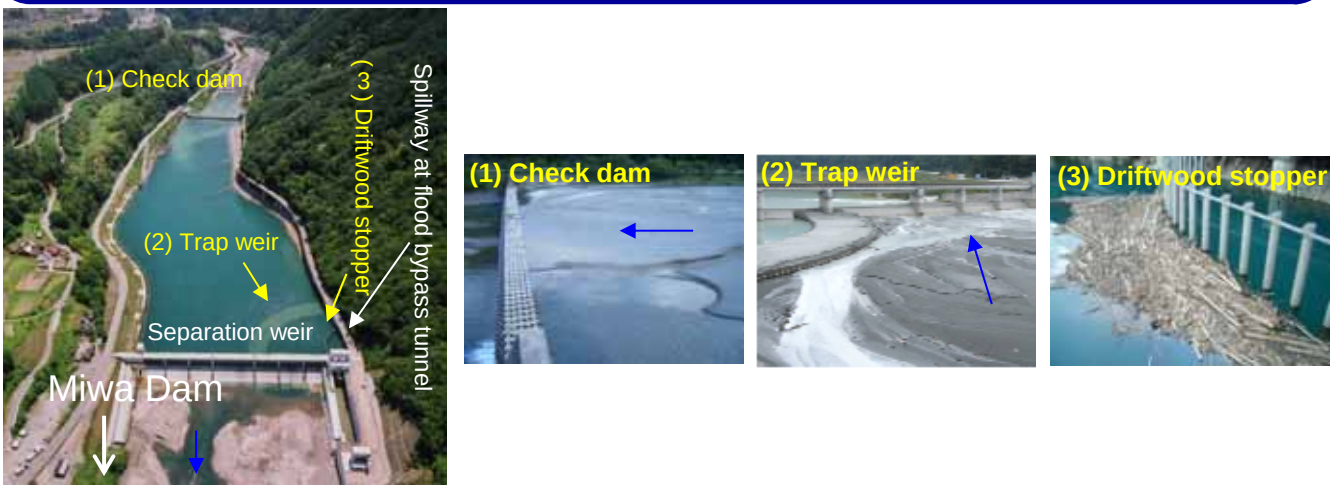


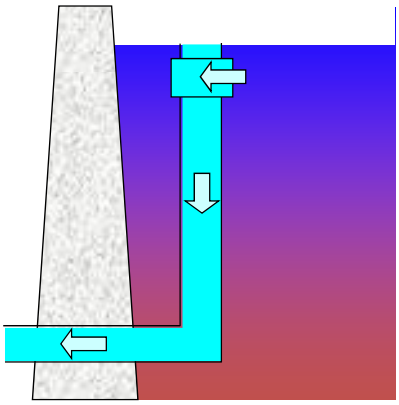
Fig.5-4 Miwa Dam

6. Technologies to improve environments

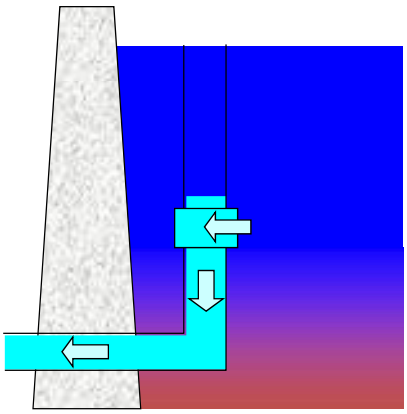
6-1 Adopting selective intake facilities

Controlling water temperature in the downstream river.

- Yokoyama Dam in Gifu Pref.(Fig.6-1)
- Benoki Dam in Okinawa Pref. etc.



◇ Water intake at the upper part



◇ Water intake at the lower part

Fig.6-1 Yokoyama Dam

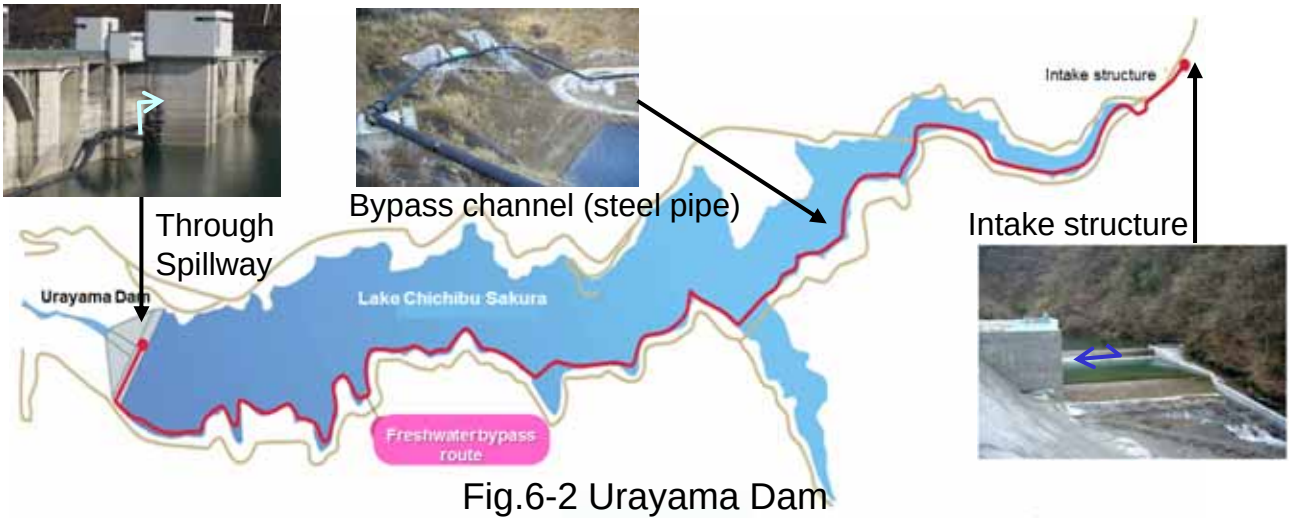
6-2 Bypassing fresh water directly from the upstream to the downstream river

Maintaining the downstream water environment, even when the reservoir environment is temporarily degraded.

- Urayama Dam in Saitama Pref.(Fig.6-2)
- Miharu Dam in Fukushima Pref. etc.

Through Spillway

Bypass channel (steel pipe)



Intake structure

Fig.6-2 Urayama Dam

6-3 Adding new aerators

Reducing the amount of blue-green algae.

- Urayama Dam in Saitama Pref.(Fig.6-3)
- Kamafusa Dam in Miyagi Pref. etc.

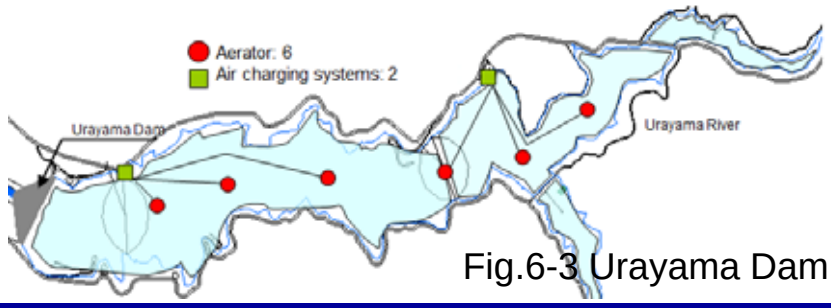
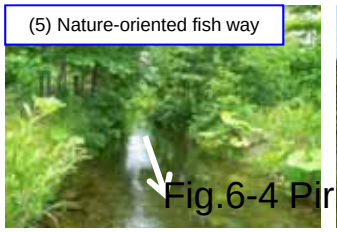


Fig.6-3 Urayama Dam

6-4 Adding facilities such as fish ways to conserve the ecosystem

Guiding fish through the dam reservoir.

- Pirika Dam in Hokkaido Pref. (Fig.6-4)
- Samani Dam in Hokkaido Pref. etc.



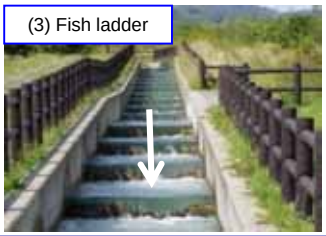


Fig.6-4 Pirika Dam

Upgrading of operating dams

(Ongoing major national projects)

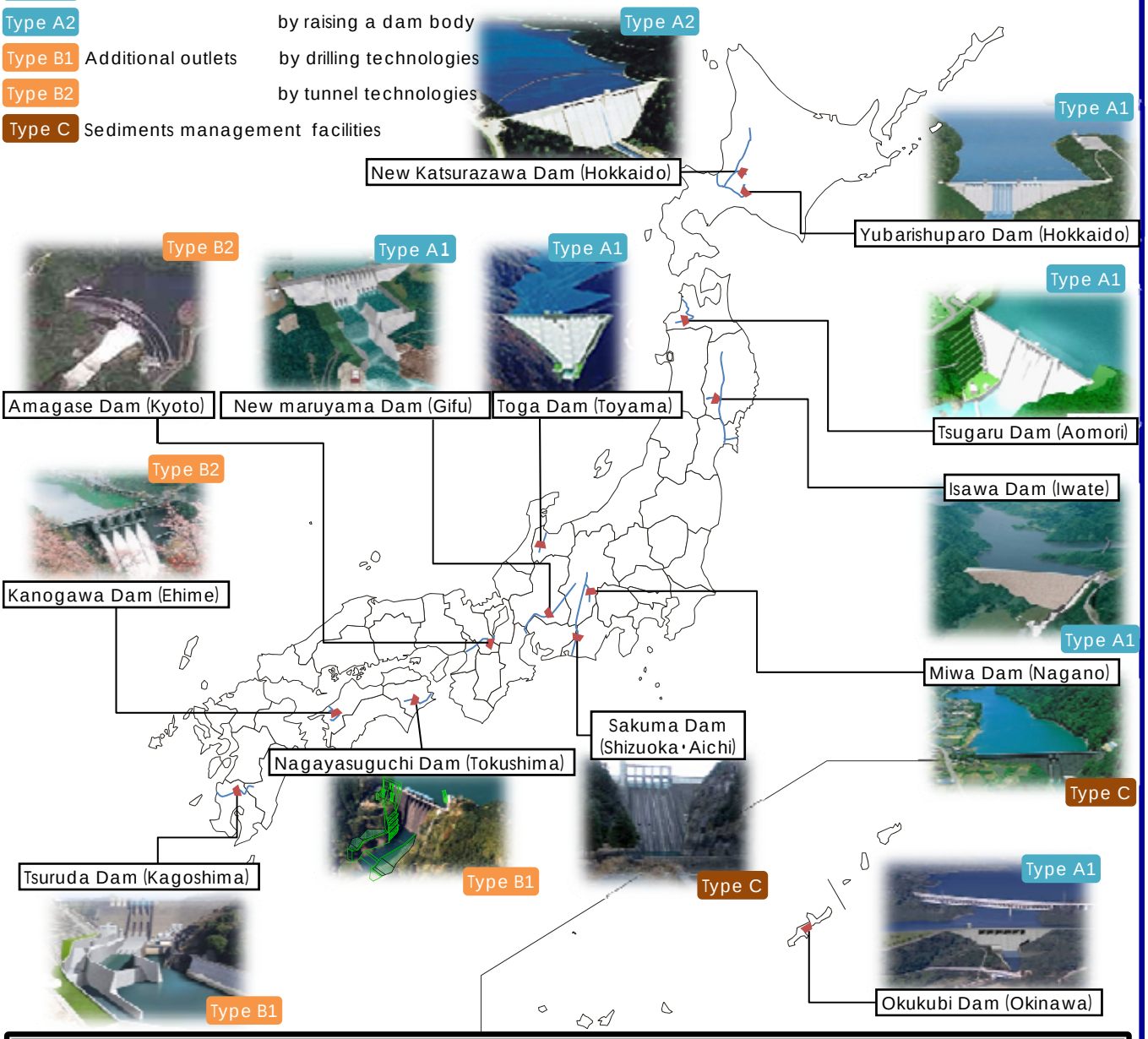
Type A1 Increasing capacities by constructing a new dam body

Type A2 by raising a dam body

Type B1 Additional outlets by drilling technologies

Type B2 by tunnel technologies

Type C Sediments management facilities



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