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 Engineering Center
Japan Association of Dam & Weir Equipment Engineering
Japan Dam Foundation
WEC
Japan Water Agency
Public Work Research Institute

Water and Disaster Management Bureau
Ministry of Land, Infrastructure, Transport and Tourism
MLIT executes comprehensive water management

<table>
<thead>
<tr>
<th>Planning</th>
<th>Decides long term visions and mid term plans for flood control and water resource development.</th>
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<tr>
<td>Coordinating</td>
<td>Coordinates parties which are stakeholders in water.</td>
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<td>Implementing</td>
<td>Acts as the headquarter for river improvement projects and dam projects including dam upgrading.</td>
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<tr>
<td>Accumulating</td>
<td>Accumulates technical knowledge related to river projects in cooperation with the NILIM and PWRI and other R&amp;D institutions.</td>
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Image of upgrading dam under operation

SOCIAL IMPACTs
- Almost no impact on the local society
- Necessity to reconstruct the local society

Environmental assessment

ENVIRONMENTAL IMPACTs
- Almost no impact on animals and plants
- Necessity to mitigate impacts on animals and plants

Upgrading the dam (ongoing) Building a new dam (reconstruction)

Substitute roads & negotiating reconstruction

Upgrading dam is **more reasonable, short-term, and ecological work** than a new dam building.
## Technologies to upgrade dams under operation

### 1. Technologies to increase reservoir volume

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

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

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

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

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

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.

![Diagram of New Katsurazawa Dam](image)

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

![Diagram of Kasabori Dam](image)

**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.

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.
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](image1)

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.

![Fig. 2-2 Tsuruda Dam](image2)
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.

Figure 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.

Figure 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.

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.

Fig. 3-1 Sayamaike Dam

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)

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

- 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)

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

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.

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.
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.

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.4-3 Isawa Dam

Gathering data on a continuously operating dam

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.

Conceptual diagram

Koshibu Dam
Separation weir
Sediment weir
Sediment bypass tunnel

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.

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.
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.

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.

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](image)

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](image)
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

New Katsurazawa Dam (Hokkaido)
Yubarishuparo Dam (Hokkaido)
Tsugaru Dam (Aomori)
Isawa Dam (Iwate)
Toga Dam (Toyama)
Tsugaru Dam (Aomori)

New maruyama Dam (Gifu)
Okukubi Dam (Okinawa)
Kanogawa Dam (Ehime)
Tsuruda Dam (Kagoshima)

Miwa Dam (Nagano)
Sakuma Dam (Shizuoka, Aichi)
Nagayasuguchi Dam (Tokushima)

Kuroki Dam (Kagoshima)
Tsuruda Dam (Kagoshima)

Contact us:
Japan Commission on Large Dams (General)
E-mail: secretariat@jcold.or.jp  Tel: +81-3-3459-0946

Japan Dam Foundation (for technical matters concerning constructing dams)
E-mail: mizuki@jdam.jp  Tel: +81-3-3545-8361

Japan Dam Engineering Center (for technical matters concerning R&D of dams)
E-mail: jdec_inquiry@jdec.or.jp  Tel: +81-3-5815-4161

Japan Association of Dam & Weir Equipment Engineering (for mechanical matters concerning dams and weirs)
E-mail: dam@river.ocn.ne.jp  Tel: +81-3-3267-0371

Water resources Environment Center (for environmental matters concerning R&D of dams)
E-mail: wechome@wec.or.jp  Tel: +81-3-3263-9923

Japan Water Agency
E-mail: jwa_international@water.go.jp  Tel: +81-48-600-6553

Public Works Research Institute
E-mail: dam_str@pwri.go.jp  Tel: +81-29-879-6781

River Planning Division, Water and Disaster Management Bureau, MLIT, JAPAN
E-mail: river_kokusai@mlit.go.jp  Tel: +81-3-5253-8444

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