Maintenance and Utilization of a Sabo Facility Designated as an Important Cultural Property - The Shiraiwa Sabo Dam -

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This report introduces the effort of maintenance and utilization of Tateyama Mountain Area Sabo office against maintenance and management issues surrounding modern sabo works. The maintenance of the Shiraiwa Sabo Dam is described, particularly in the context of maintaining its disaster prevention function and conserving its value as a cultural property. It is hoped that this report on the Shiraiwa Sabo Dam will help guide the maintenance and management of other Sabo facilities designated as Important Cultural Properties.

Key words: Historic sabo facilities, Important Cultural Property, maintenance of sabo facilities, disaster-prevention, cultural value

1. Introduction

Sabo work in Tateyama started in 1906. The initial sabo works were undertaken by Toyama Prefecture. At that time, construction of structures such as sabo dams was very difficult and expensive.

Consequently, direct control of sabo works was handed to the Ministry of Home Affairs (now the Ministry of Land, Infrastructure, Transport and Tourism, MLIT) in 1926.

Over the next 90 years, many advances were made to sabo design and construction. The Shiraiwa Sabo Dam was the first sabo facility built by the Ministry at the Tateyama Caldera; it is an important sabo facility that prevents sediment discharge from the Tateyama Caldera.

The Shiraiwa Sabo Dam continues to be an important disaster-prevention measure. In addition, the historical and cultural value of the Shiraiwa Sabo Dam was recognized by the Agency for Cultural Affairs in June 2009, when it became the first sabo dam in Japan to be designated as an Important Cultural Property.

This paper reports on the maintenance and management of the Shiraiwa Sabo Dam, and examines the goal to preserve both the dam's original disaster-prevention function and its value as a cultural property.

2. Overview of the Sabo works in Tateyama

2.1 Overview of the Joganji River

Toyama Prefecture is located in the central part of Japan. The prefecture area is about 4,300 km^2, occupying approximately 1% of the total area of Japan, and the prefecture population is about 1.1 million, approximately 1% of Japan's total population. Toyama Prefecture is surrounded by high mountains to the east, south, and west. About 72% of the prefecture is occupied by mountains and hills with an altitude of 100 m or more. There is abundant rain fall in the winter, and precipitation in the mountains exceeds 5,000 mm per year.

The Joganji River is one of steepest rivers in Japan, flowing 56 km from the 3,000 m-high mountainous area in the east of Toyama Prefecture to Toyama bay. The average slope of the riverbed is about 1/30 (**Fig. 1**). In the upstream area of the Joganji River lies the Tateyama Caldera, which extends 6.5 km east-west and 4.5 km north-south, and has a fragile geology composed of Tateyama Volcano ejecta. In addition, the Atotsugawa fault, which is prone to collapse, lies in the vicinity.

During the 1858 Hietsu earthquake (magnitude 7.1), a gigantic landslide, named the Tonbi landslide, occurred at the Tateyama Caldera, and about 400 million m^3 of sediment accumulated, of which 200 million m^3 flowed out of the caldera.

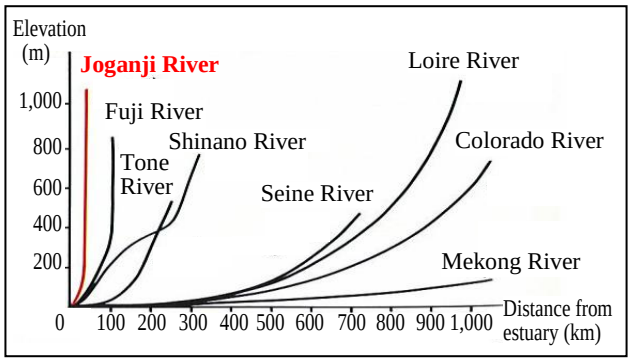

Fig. 1 Slope of the Joganji riverbed relative to other of other rivers

As a result, 140 people died, and 8,945 people were injured. After this disaster, the Joganji River became more prone to additional sediment-related disasters.

2.2 Outline of the sabo works in the Tateyama Mountain Area

In the Tateyama Caldera, there is still about 200 million m^3 of accumulated sediment, some of which flows to the downstream area of the Joganji River every time heavy rainfall occurs.

To protect the Joganji River Basin from sediment-related disasters, modification of the Joganji River began in the Meiji era, but disasters still occurred repeatedly. In 1906, sabo works started in the upstream area of the Joganji River.

However, several major sabo facilities were destroyed by a large flood in 1919, and there were difficulties associated with the cost and construction of the sabo works. At the request of Toyama Prefecture, direct control of the Sabo works was handed to the Ministry of Home Affairs (now the Ministry of Land, Infrastructure, Transport and Tourism, MLIT) in 1926.

3. Historical sabo facilities

3.1 Historical sabo facilities in the Tateyama Mountain Area

Within the management area of the Tateyama Mountain Area Sabo Office, there are many (about 30%) sabo dams that were completed over 50 years ago or more, such as the Shiraiwa Sabo Dam, Yukawa Sabo Dam, Matsuo Sabo Dam, Onigajo Sabo Dam, and Sabudani Sabo Dam.

Since their completion, these sabo facilities have protected, and continue to protect, the Joganji River Basin from sediment-related disasters.

3.2 Shiraiwa Sabo Dam

The Shiraiwa Sabo Dam is an important sabo facility constructed between October 1929 and December 1939. The dam was constructed based on a plan designed by Masao Akagi, an engineer for the Japan Department of Interior, to stabilize the hillside of the Joganji River upstream area, including the Tateyama Caldera, and to prevent erosion of the river bed.

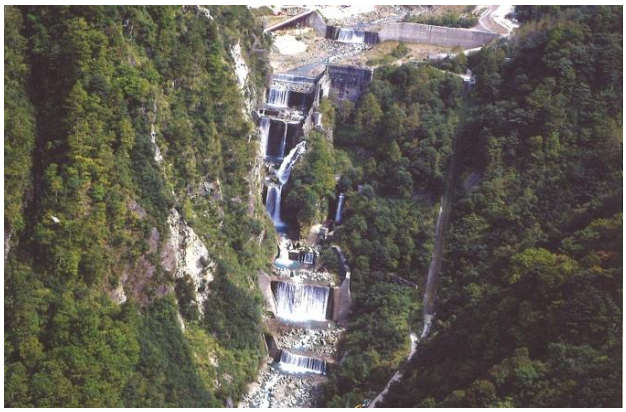

Fig. 2 Shiraiwa Sabo Dam

The Shiraiwa Sabo Dam was constructed at the outlet of the Tateyama Caldera in the upstream area of the Joganji River (41.8 km from the river's estuary). This location was chosen for the dam construction site due to the suitable rock foundation, and the ability to secure a large sedimentary area at a narrow part of the river. The Shiraiwa Sabo Dam is a complex sabo facility including a main dam with a non-overflowing section height of 63 m (Japan's largest), seven counter dams, and a retention frame. In addition, this was the first sabo dam in Japan for which a seismic design method was used.

In Japan, sabo facilities that still exist more than 50 years after completion, and are deemed to have historical and cultural value, are defined as Historical Sabo Facilities. Sabo dams with particularly high value are recognized as Cultural Properties by the Agency for Cultural Affairs, Government of Japan.

The Shiraiwa Sabo Dam was built using the seismic design method, with large machines that were considered state-of-the-art technology at the time. It is a complex sabo facility, composed of multiple large-scale structures. The Shiraiwa Sabo Dam has been deemed "particularly technically superior," "highly historical," and "a great technical achievement among modern sabo facilities". In June 2009, it was the first sabo facility in Japan to be designated an Important Cultural Property.

The Shiraiwa Sabo Dam is composed of many facilities, including the main dam, the retention frame, and a number of counter dams. The extent of the Important Cultural Property designation is shown in **Fig. 3**.

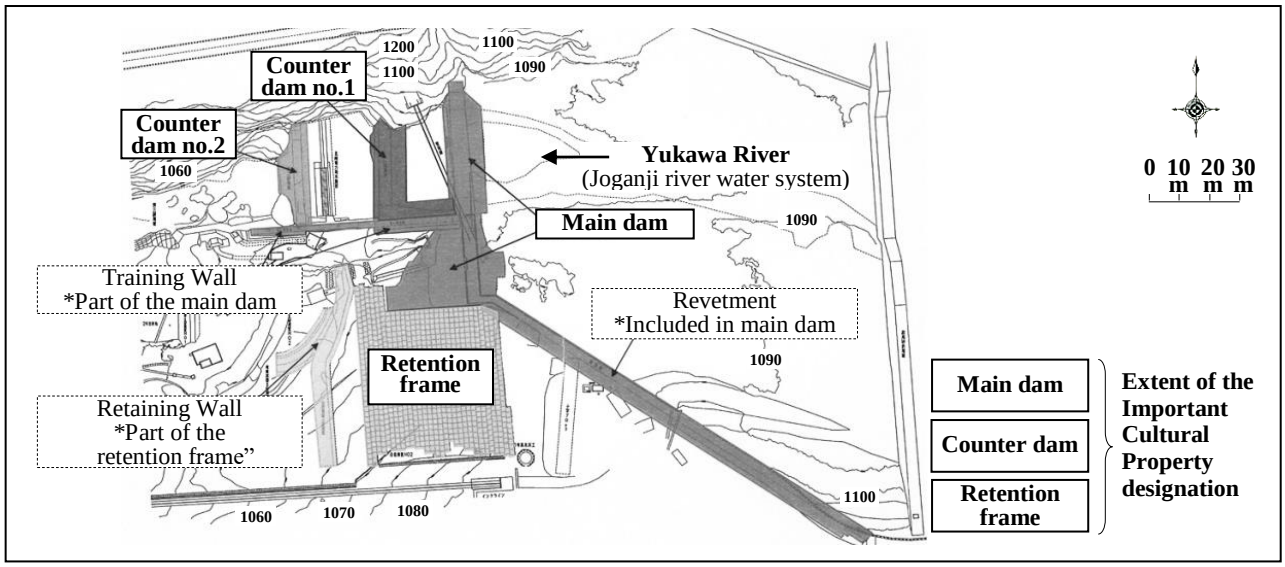

Fig. 3 Extent of the Important Cultural Property designation of the Shiraiwa Sabo Dam

3.3 Hongu Sabo Dam

The Hongu Sabo Dam is a main check dam that was constructed between 1935 and 1937 in the midstream area of the Joganji River (26.8 km from the estuary), for the prevention and control of sediment discharge.

The dam height is 22.0 m and the crest length is 107.4 m; a total of 23,500 m^3 of concrete was used in the construction of the dam body. There are five counter dams, and the sediment trap capacity is the largest in Japan, at 5 million m^3.

At the time of construction of the Hongu Sabo Dam, large-scale state-of-the-art equipment and methods, such as tower cranes, were introduced. Therefore, despite its large scale, the dam was completed in less than 2 years (**Fig. 4**).

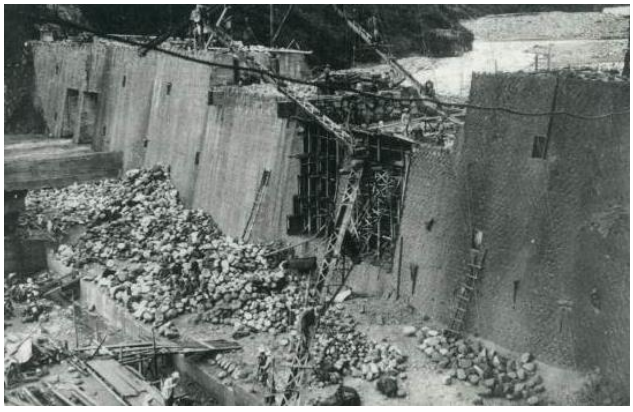

Fig. 4 Hongu Sabo Dam (under construction)

The Hongu Sabo Dam has been highly praised for demonstrating "the technical level of sabo facility design in the early Showa period". The dam has been deemed a "valuable example of mechanized construction techniques". In November 2017, the Hongu Sabo Dam was designated an Important Cultural Property (**Fig. 5**).

Fig. 5 Hongu Sabo dam (present day)

3.4 Dorodani Sabo Dams

The Dorodani Sabo Dams were constructed just under the Tonbi landslide area to prevent devastation of the Dorodani valley (**Fig. 6**). The Dorodani Sabo Dams are a series of stepped dams consisting of 20 check dams, 3 groundsills, and hillside works.

Initially, Toyama Prefecture constructed sabo facilities in Dorodani, but these were damaged during the heavy rains of 1929. The Ministry of Japan started re-construction of the Dorodani Sabo Dams in 1930 (**Fig. 7**).

The Dorodani Sabo Dams have also received praise for showing "the technical level of sabo facility design in the early Showa period" and for the value of its "hillside works to prevent slope failure". In November 2017, the Dorodani Sabo Dams were designated an Important Cultural Property.

Fig. 6 Dorodani Sabo Dams (under construction)

Fig. 7 Dorodani Sabo Dams (present day)

4. Problems and solutions for sabo facilities in Japan

4.1 Deterioration of infrastructure

A large proportion of Japan's infrastructure, such as roads, bridges, and river management facilities, was constructed during the high growth period after World War Ⅱ. Thus, 10 years from now, many of these facilities will have been in place for about 50 years. Twenty years from now, 60% of all sabo facilities will be at least 50 years old. Therefore, there is concern about the deterioration of this infrastructure.

4.2 Plan to prolong the lifespan of Japan's infrastructure

In December 2012, the ceiling board of a tunnel fell onto the Chuo Expressway, one of the major expressways of Japan. This event prompted the MLIT to create a plan to prolong the lifespan of Japan's infrastructure (hereafter referred to as the Action Plan), in September 2013. Based on this plan, the MLIT began taking appropriate action to maintain and prolong the lifespan of Japan's infrastructure.

4.3 Approach of the Erosion and Sediment Control Department of the MLIT

Sabo facilities prevent sediment-related disasters, and their functions (**Table 1**) must be sustained.

Table 1 Major functions of sabo facilities

Debris flow control
Landslide control
Prevention of steep slope failure

To maintain sediment-related disaster protection, the Erosion and Sediment Control Department of the MLIT ordered all sabo offices in Japan to develop a plan to prolong the lifespan of sabo facilities, based on MLIT's Action Plan.

In addition, the Erosion and Sediment Control Department of the MLIT issued manuals to sabo offices, which were designed to help facility managers investigate the soundness of existing facilities and plan lifespan-prolonging maintenance activities (**Fig. 8**).

4.4 Action at the Tateyama Mountain Area Sabo Office

The Tateyama Mountain Area Sabo Office is currently implementing a plan to maintain and prolong the lifespan of Sabo facilities in accordance with the manuals issued by the MLIT.

The main tenets of the Tateyama Mountain Area Sabo Office plan are shown below.

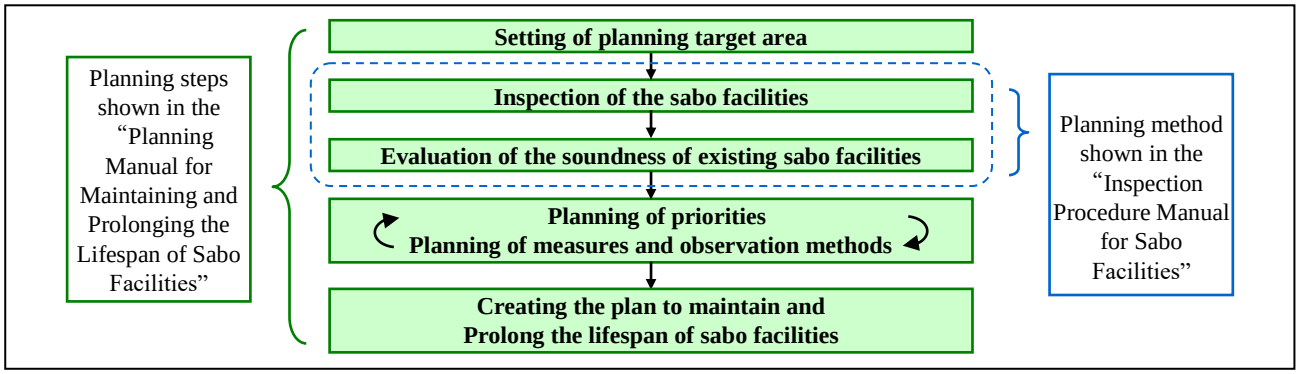

Fig. 8 Contents of the "Planning Manual for Maintaining and Prolonging the Lifespan of Sabo Facilities" and the "Inspection Procedure Manual for Sabo Facilities"

(1) Inspect and evaluate the soundness of sabo facilities.

We will conduct periodic, detailed inspections to evaluate any deterioration of facility functions or performance, based on structural and material characteristics. Using the results of the inspections, we will comprehensively evaluate the soundness of the facilities (**Fig. 9**).

The characteristics of materials and structures that are not currently used, such as stone and concrete rubble, will be considered.

In addition, facilities that have been deemed Important Cultural Properties will be carefully inspected and scrutinized via detailed inspection, boring surveys, elastic wave surveys, etc., to maintain their status as Important Cultural Properties (**Table 2**, **Fig. 10**).

(2) Planning of priorities for corrective measures.

At the Tateyama Mountain Area Sabo Office, the priority for implementing corrective measures was determined using multiple evaluation indicators, as shown in **Table 3**.

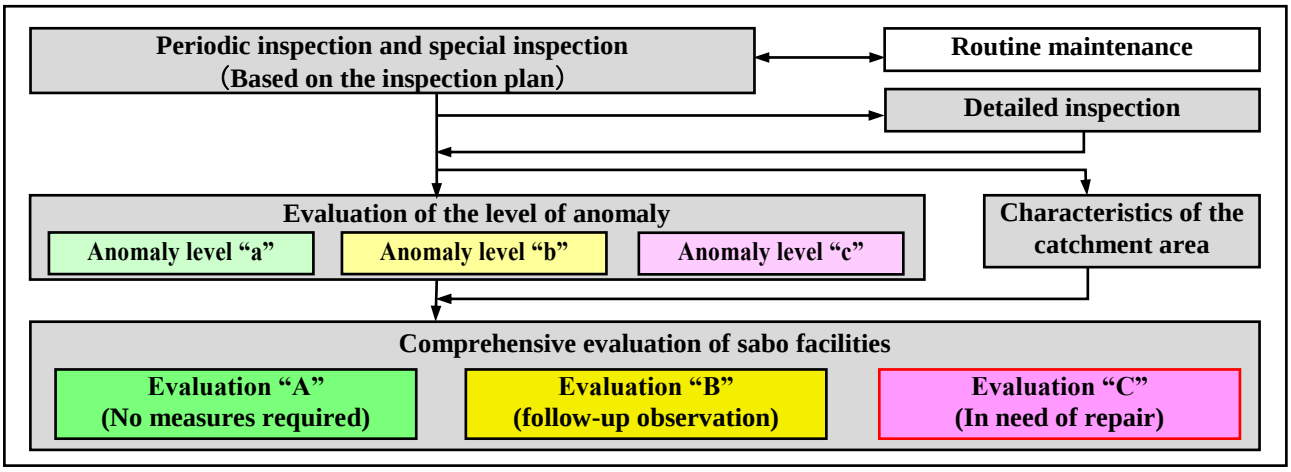

Fig. 9 Comprehensive evaluation of sabo facilities

Table 2 Examples of detailed inspection items for historical Sabo facilities

Investigation method	Investigation aims	Description
Boring investigation	To determine the physical properties of the internal material of the dam and sedimentation area	In-situ test and laboratory tests
Detailed visual inspection	To determine characteristics (material, color, shape, arrangement) and damage or deterioration of the outer stone material	Carried out by researchers with expertise using appropriate technology
Elastic wave exploration	To determine the density of the internal material	Non-destructive inspection

Fig. 10 Example images of detailed visual inspections of sabo facilities

Table 3 Indicators for determining the priority of corrective measures

Indicator	Contents	Evaluation A	Evaluation B	Evaluation C
Soundness of the facilities	Results of the soundness evaluation of the facilities	No need to repair sabo facilities	Follow-up observation of sabo facilities	In-need-of-repair sabo facilities
Core facility determination	Core facility of the basin	Not a Core facility of the basin	—	Core facility of the basin
Stability of the facility	Results of the stability check	Stable	Metastable	Unstable
Flow capacity	Flow capacity of the overflow section of the facility	Water flow	Water barely flows	Water does not flow
Importance of the facility	Type of torrent	Not applicable; debris flow torrent	—	Applicable; debris flow torrent
	Sediment trap capacity	≤ 100,000 m^3	100,000–430,000 m^3	≥ 430,000 m^3
Distance to conservation target	Distance from sabo facilities to the conservation target (houses, public facilities, power stations, etc.)	≥ 1.0 km	0.1–1.0km	≤ 0.1 km
Support in the event of a disaster	Facilities covering areas in which people who need disaster support reside.	Not in the torrent	—	Within the torrent
Characteristics of the basin	Sediment movement potential in basin	Low	Medium	High
	Deep-seated landslide zone	Not applicable	—	Applicable

(3) Creating a maintenance and life-prolonging plan for the sabo facilities.

The measures were determined based on the extent of damage and local situation. Measures that have already been implemented were selected (**Table 4)**.

5. Preservation of cultural properties in Japan

5.1 Schematic diagram of cultural properties

To protect precious historical cultural properties, the Law for the Protection of Cultural Properties was enacted in Japan.

Cultural properties include structures such as shrines and private houses; artifacts such as Buddhist statues, paintings, and calligraphy; manners and customs; traditional events and festivals; and landscapes, historic villages, and townscapes (**Fig. 11**).

5.2 Movements to protect the cultural value of Sabo facilities

In Japan, sabo facilities have been constructed for over 100 years, to recover devastated mountains and prevent sediment-related disasters. Sabo facilities were built using the technology available at the time of construction, and though some of these construction methods are now outdated, the facilities themselves still continue to function as disaster prevention systems.

Japan's Agency of Cultural Affairs feared that various historical structures that contributed to the modernization of Japan were being destroyed, without being evaluated. In 1996, the Agency of Cultural Affairs revised the laws regarding protection of cultural properties, established a "Registered Cultural Property System," and began protecting historical structures, including sabo facilities, as cultural properties.

To register a sabo facility as a Tangible Cultural Property, it is necessary to evaluate, preserve and use it as a cultural property based on its characteristics. For this reason, the MLIT and the Agency of Cultural Affairs held a committee meeting on the preservation and utilization of historical sabo facilities in December 2002, and established guidelines for the preservation and utilization of historical sabo facilities in May 2003.

In September 2003, the MLIT notified the Sabo facility administrators about these guidelines, which were used as a basis for preservation and utilization as cultural properties.

In May 1997, the Katsunuma Sabo Dam became the first Sabo facility to be registered as a Tangible Cultural Property. Since then, over 160 Sabo facilities have been registered as Tangible Cultural Properties.

In June 2009, the Shiraiwa Sabo Dam was the first sabo facility to be designated an Important Cultural Property in Japan. In July 2012, the Ushibuse River French-style channel works system was also designated as an Important Cultural Property. In addition, in November 2017, the Hongu Sabo Dam and Dorodani Sabo Dams, which are under the jurisdiction of the Tateyama Mountain Area Sabo Office, were designated as Important Cultural Properties.

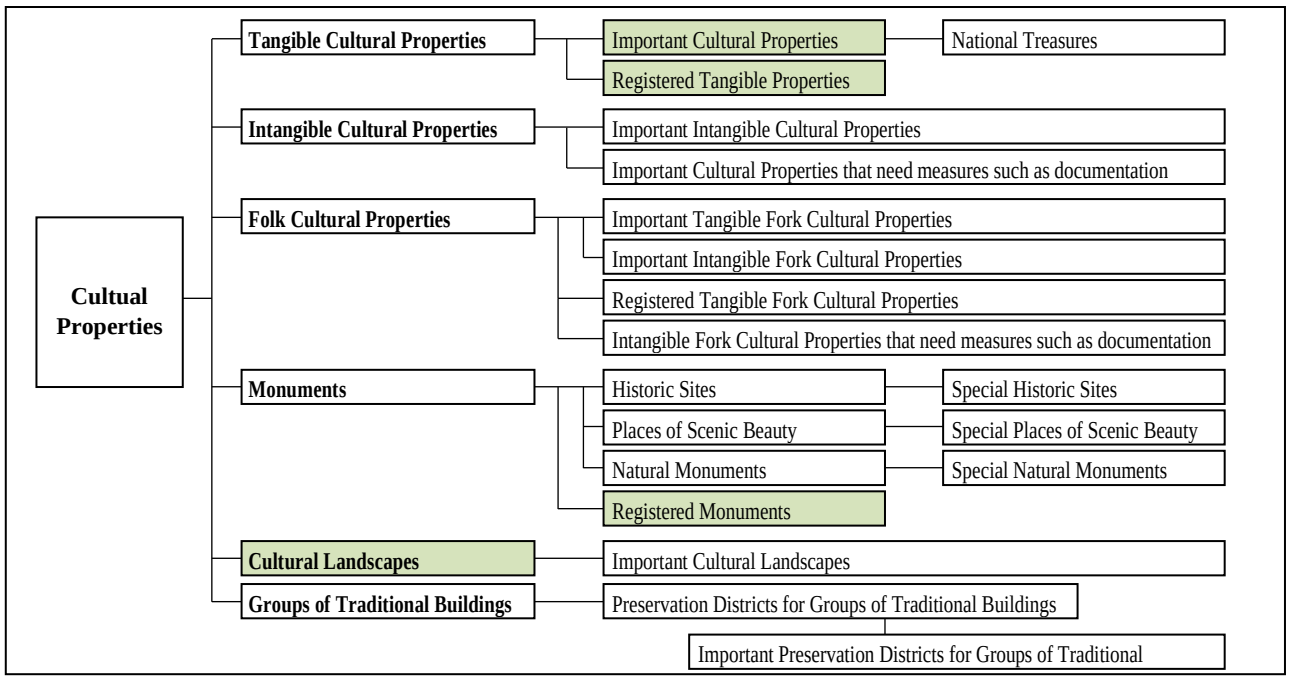

Fig. 11 Schematic diagram of cultural properties

6. Preservation of the historical cultural value of sabo facilities

The purpose of historical sabo facility management efforts by the Tateyama Mountain Area Sabo Office is to maintain the disaster prevention functions of the facilities and preserve their value as cultural properties. In particular, management of the Shiraiwa Sabo Dam, designated as an Important Cultural Property, was discussed with the Agency for Cultural Affairs. In accordance with the "Guidelines for the Preservation and Utilization of Important Cultural Properties" established by the Agency for Cultural Affairs, a preservation plan for the Shiraiwa Sabo Dam was established and is currently in operation.

Some of the key details of this plan are described below.

(1) Fundamental policies

The fundamental policies for conservation and management of the Shiraiwa Sabo Dam are:

a) Maintain disaster prevention functions
b) Avoid modifications where possible
c) Classify the structures and materials
d) Accelerate and simplify response measures

(2) Policy for conservation.

The Agency of Cultural Affairs' "Guidelines for the Preservation and Utilization of Important Cultural Properties" requires the establishment of "parts" and "positions" for the target facilities, and the formation of conservation policies.

The Shiraiwa Sabo Dam is a complex structure including the main dam, seven counter dams, a retention frame, and a retaining wall.

The Important Cultural Property designation includes the main dam, counter dams nos. 1 and 2, and the retention frame.

In the Shiraiwa Sabo Dam conservation and management plan, the main structures were classified as "parts" (**Tables 5** and **6**).

Each individual "position" is categorized according to the construction materials used. To preserve the value of Important Cultural Properties, the Tateyama Mountain Area Sabo Office has established four standards for the preservation of material characteristics such as shape, finish, and color, and has applied these standards to each "position" (**Fig. 12, Table 7**).

Table 5 Parts and component of the Shiraiwa Sabo Dam

Part	Component
Main dam	Overflow section of the main dam
	Non-overflow section of the main dam
	Revetment nos. 1–4
	Training walls nos. 1 and 2

Table 6 Parts and component of the Shiraiwa Sabo Dam

Part	Component
Counter dam no.1	Counter dam no.1
	Training levee no.3
Counter dam no.2	Counter dam no.2
Retention frame	Retention frame
	Retaining wall

Table 7 Policy for the conservation of each "position" of the Shiraiwa Sabo Dam

	Policy for conservation of each position		Example of the corresponding position
	If the facility is damaged or deteriorated, repairs must be made using materials that are the same or almost the same as the original materials. Repairs must be carried out in a manner that does not degrade the cultural value of the facility.		
Part to be conserved Part composed of "positions" corresponding to standards 1–2	**Standard 1**	**Positions that must be repaired using materials having the same shape, finish, and color as the originals.** The repair is made using the original material. If this is not possible, the repair is made using a material with the same shape, finish, and color.	Stone materials Retention frame (reinforced concrete bar)
	Standard 2	**Positions that must be repaired using materials having the same shape and color as the originals.** The repair is made using the original material. If this is not possible, the repair is made using a material with a similar shape and color.	Rubble concrete
	Standard 3	**Positions that must be repaired with due consideration for of compatibility with the surrounding design.** Repairs should be made with consideration to the surrounding design, when changes are required to maintain or reinforce the facilities.	Raised position of the dam
Other parts	**Standard 4**	Except for countermeasures for the repair and prevention of damage during a disaster, will be left in its current state.	Side wall of diversion channel no. 2 Masonry retaining wall of diversion channel no. 2

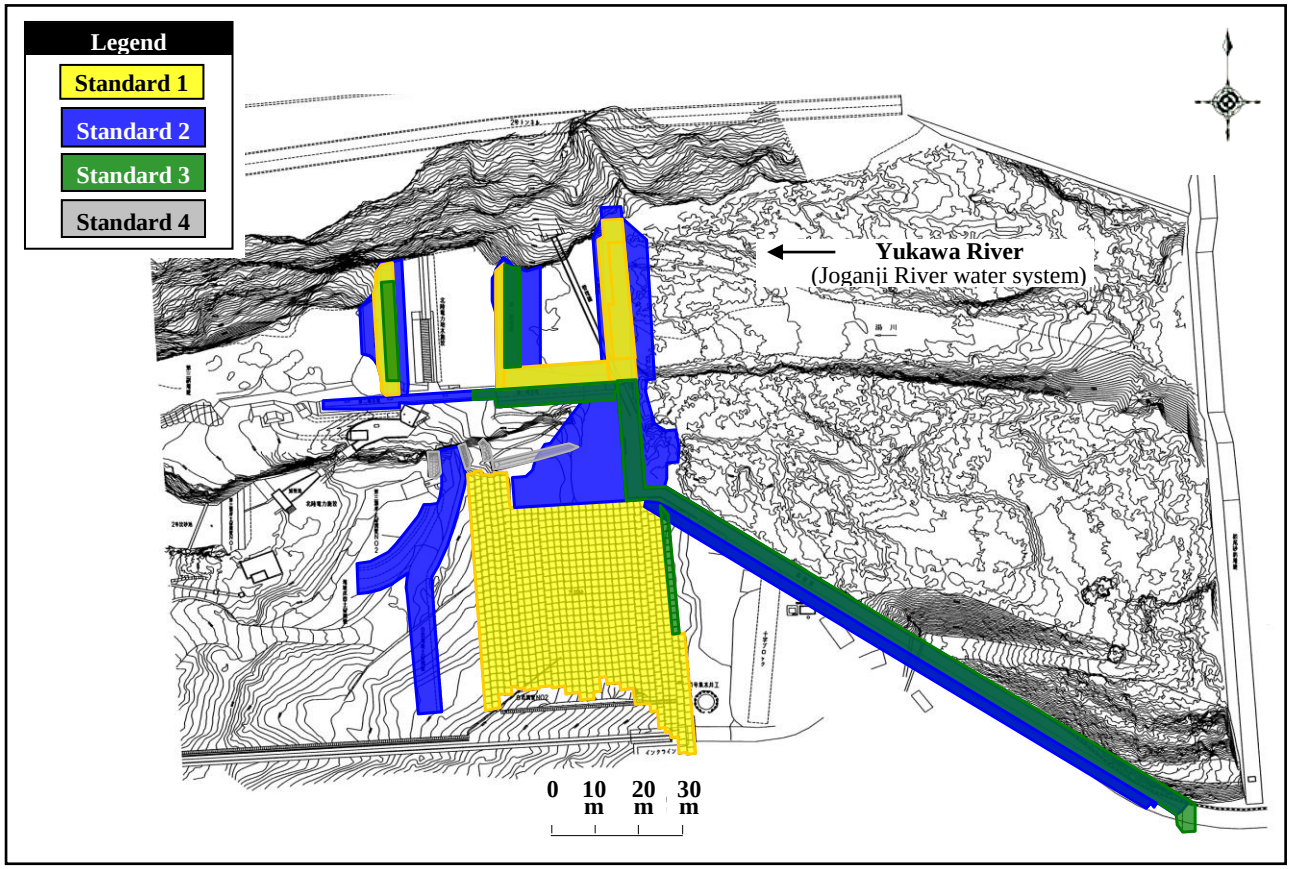

Fig. 12 Extent of the Important Cultural Property designation and standards for the conservation of each "position" of the Shiraiwa Sabo Dam

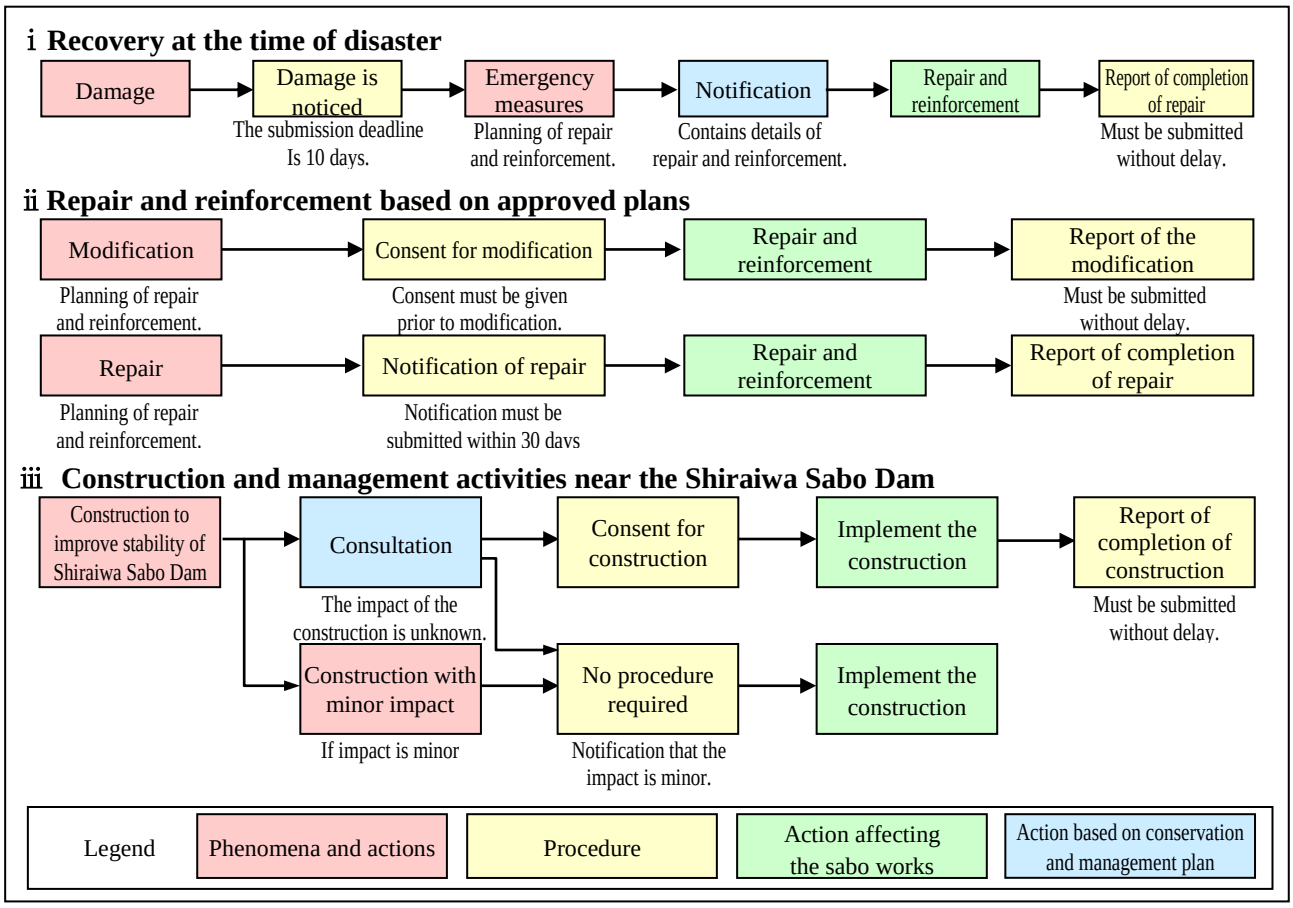

Fig. 13 Basic process flow diagram

(3) Preservation of the value of Important Cultural Properties and maintenance of disaster prevention functions

In general, when an important cultural property is damaged and subsequently repaired or reinforced, it is necessary to confer with the Agency of Cultural Affairs, and the repair often takes a significant amount of time.

However, the Shiraiwa Sabo Dam is a disaster prevention facility, so repairs and reinforcement must be carried out quickly to protect the Joganji River basin from sediment-related disasters.

Therefore, the Tateyama Mountain Area Sabo Office has already convened with the Agency for Cultural affairs regarding how to make repairs to the Shiraiwa Sabo Dam, and how best to cooperate with related organizations (**Fig. 13**).

7. Examples of utilization of sabo facilities at the Tateyama Mountain Area Sabo Office

7.1 Education

The Tateyama Mountain Area Sabo Office utilizes the sabo facility and its surrounding area to provide education about the sabo works, and to improve regional disaster prevention abilities.

Since sabo facility construction/operation is still ongoing in the Tateyama Caldera, entrance to the general public is restricted. However, the Sabo works are used as an “experiential learning” facility, operated by the administrative inspection team and the Toyama Prefectural Caldera Sabo Museum (see **Fig. 14** and **15**).

The Tateyama Mountain Area Sabo Office also dispatches lecturers to provide extracurricular lessons about the sabo works.

Fig. 14 Experiential learning at the observation deck above the Rokkyu-Dani valley

Fig. 15 Experiential learning at the ruins of the Tateyama Hot Springs

Table 8 Number of participants in dam activities by year.

Year	Government inspection	Experience & study tours	Extracurricular lessons
2013	625	716	0
2014	751	1,043	0
2015	761	914	41
2016	538	904	83
2017	539	640	378

7.2 Utilization of the facility as a regional revitalization resource

Historical sabo facilities are valuable assets that contribute to regional revitalization. It is important to appropriately evaluate and preserve these facilities, and to make appropriate use of the facilities and surrounding areas.

The Tateyama Mountain Area Sabo Office preserves the historical cultural values of Sabo facilities. The area around the Hongu sabo Dam is being developed by the Joganji River Waterfront School project (**Fig. 16**), and there is also a Joganji River Waterfront School Liaison Council.

Through these initiatives, the local community is considering measures to revitalize the region.

Fig. 16 Hongu Sabo dam maintenance bridge

8. Conclusion

Sabo facilities were constructed using the materials, designs, and construction methods available at the time. These ingenious facilities were designed to protect people from sediment-related disasters in an era where modern materials and mechanized equipment did not exist. These facilities are valuable treasures that must be preserved.

It is hoped that this report on the Shiraiwa Sabo Dam will help guide the maintenance and management of other Sabo facilities designated as Important Cultural Properties.

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