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The Features of Tateyama Sabo and their Value

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Toyama Prefecture

Introduction

In Japan, sediment catching works and planting works have been conducted in various regions since the 1680s to prevent sediment-related disasters. In 1897, the Sabo Law was enacted and, in the following year, sabo works commenced in Nagano Prefecture. In Toyama Prefecture, during the 1858 Hietsu earthquake (magnitude 7.1), the massive landslide (Mt.Tonbi landslide) occurred at the Tateyama Caldera, forming landslide dams. These landslide dams collapsed twice due to snowmelt floods in the same year, and the subsequent large-scale debris flow damaged downstream areas of the Toyama Plain. Since then, efforts have been made to protect people living downstream in the Toyama Plain from the risk of huge unstable sediment within the Tateyama Caldera. Sabo works commenced over 100 years ago in the basin of the Joganji River, which is among Japan's steepest rivers, and remains active today.

Toyama Prefecture has continuously investigated the global value of the Tateyama Sabo as a legacy for future generations and a globally significant property. In this work, we summarize the status of Japan's sabo works established in upstream areas at risk of collapse, and evaluate the characteristics and accomplishments of the Tateyama Sabo.

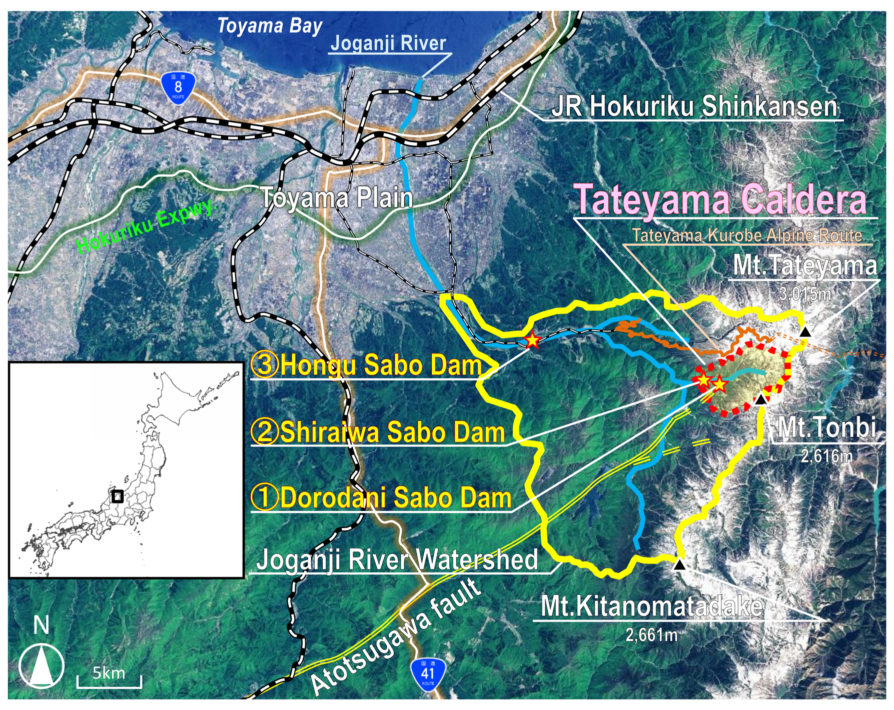

Fig.1 The Joganji River basin

Fig.2 Tateyama Caldera

Tateyama Sabo's Facilities with Long Histories

To protect people living in the Toyama Plain, downstream of the Joganji River, from repeated disasters, "Tateyama Sabo" was commenced at sites of devastation in upstream areas of the Joganji River. There are three representative historical sabo facilities in the Tateyama Sabo as shown below.

① Dorodani Sabo Dams

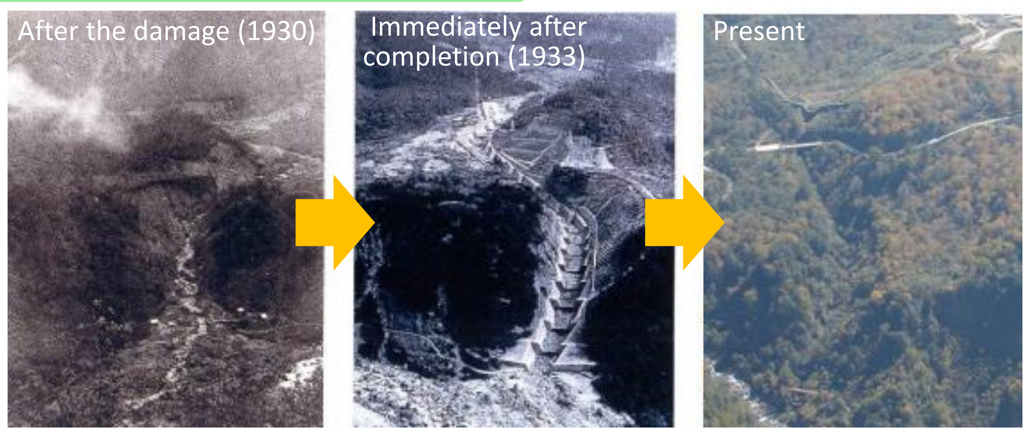

Fig.3 Changes in Dorodani

The Dorodani Sabo Dams, located at the right under of the Mt.Tonbi landslide, are made up of stepped sabo dams and hillside works which were constructed downstream of the seriously devastated.

Japan's unique hillside works such as sodding work produced a distinctive effect. Surrounded by trees and valley landscape, this sabo dam group is now a good example of achieving both disaster prevention and ecology.

② Shiraiwa Sabo Dam

Fig.4 Yukawa No.1 Sabo Dam (of the present No.1 Counter Dam of the Shiraiwa Sabo Dam)

Fig.5 Changes of The Shiraiwa Sabo Dam

The Shiraiwa Sabo Dam is located at the outlet of the Tateyama Caldera on which collapsed earth and sand accumulated. It is the core check dam of the "Overall Sabo Plan for the Joganji" designed by Akagi Masao, who is well known in Japan as the "Father of Modern Sabo Works", to raise the eroded riverbed, thus stabilizing the Tateyama Caldera and preventing sediment discharge. Construction was started in 1929 by the Tateyama Sabo Office of the former Home Ministry and completed in 1939. It is a representative Japanese sabo facility; The main dam is the highest sabo facility in Japan. It has a special composite structure, combining a gravity dam and an earth-filled embankment dam covered with the concrete-bar square frames. In consideration of the 1858 large earthquake, it was constructed using a seismic design method. It is a structure of high academic value and a system that demonstrates the technical advancement of a modern sabo facility.

③ Hongu Sabo Dam

Fig.6 Changes of The Hongu Sabo Dam

The Hongu Sabo Dam is a large-scale sabo dam constructed in the midstream of the Joganji River for sediment storage. Its construction was started in 1935 and completed in 1936. It was constructed by the Joganji River Dam Office of the former Home Ministry as part of the Joganji River Improvement Project. Construction of this dam was regarded as pre-work for the river improvement in the downstream and its primary purpose was to store sediment flowing from the upstream. The sediment-trapping capacity (5.0×10^6 m^3) is the largest of all dams in Japan.

Typical case of sabo system for integrated river system control

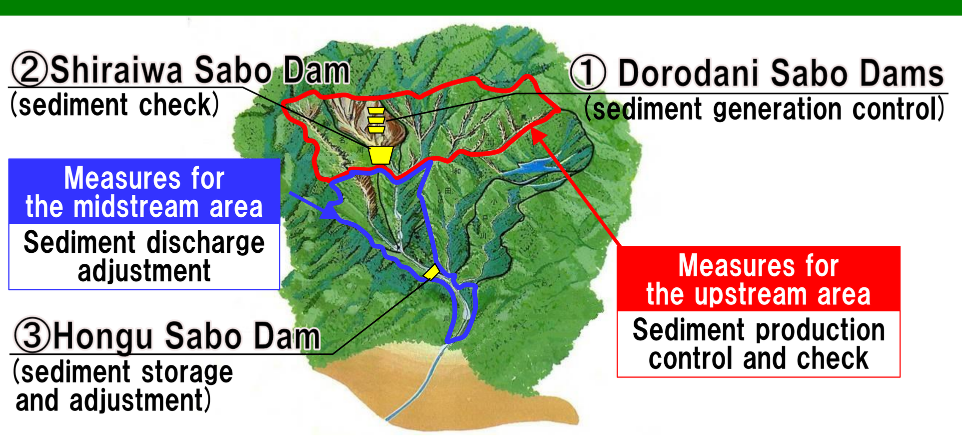

Fig.7 Comprehensive sabo system for integrated river system control

Structures that control the generation of sediments in the upstream area, namely Dorodani Sabo Dams, the structures to control sediment movement, or Shiraiwa Sabo Dam, and the structures to check and adjust sediment in the mid and downstream reach of the river, or Hongu Sabo Dam, are all major sabo dams that represent the Japanese sabo technology. These are typical sabo systems with integrated river control systems.

Large-scale Landslides and Sabo Works

Some sabo works and forest conservation projects in Japan started as a result of large-scale collapses and large amounts of sediment discharge.

Table 1 shows the history of these sabo works and forest conservation projects, as well as that of large-scale collapses in Japan, as summarized by Tsukamoto et al. (1984).

Except for the Mt. Bandai landslide, which occurred due to a steam explosion, the Mt.Tonbi, Mt.Hieda, and Oya landslides were the top three landslides in Japan in terms of estimated volume. These are called "Japan's three major landslides." In and downstream of these landslide sites, sabo works still continue.

Figure 8 shows the positions of these 3 landslide sites. Each landslide zone is located near a fault group called the Itoigawa-Shizuoka Tectonic Line.

The geology around those fault groups is very fragile due to the influence of crustal movements and weathering, and there is substantial landslide topography.

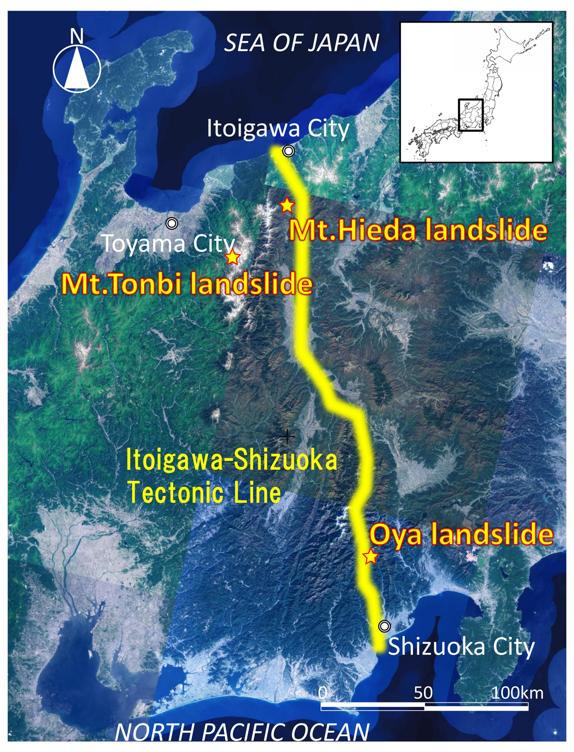

Fig.8 Positions of Japan's three major landslide sites

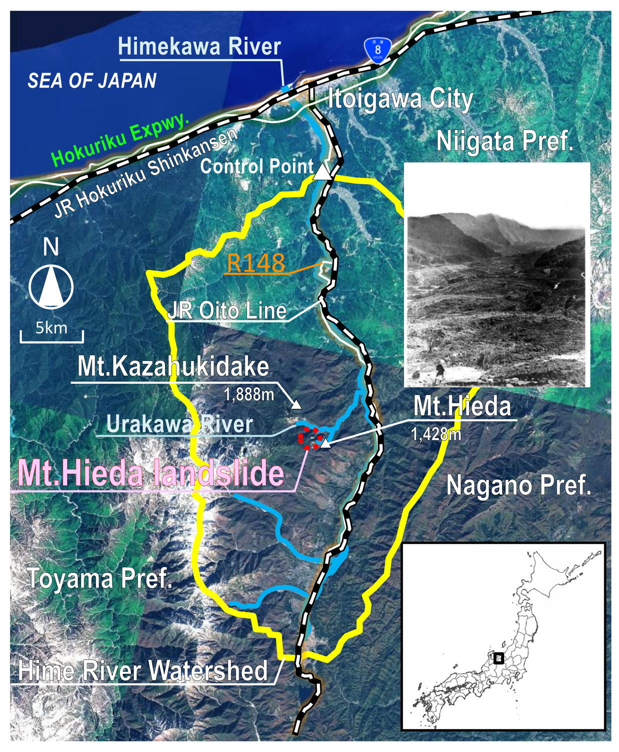

Fig.9 The Himekawa River basin

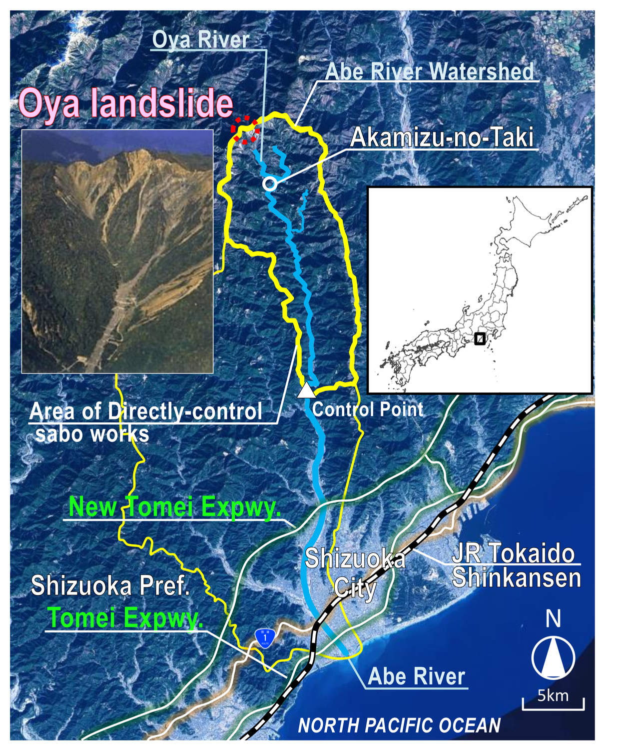

Fig.10 The Abe River basin

Table 1 History of sabo works and forest conservation projects in large-scale collapses in Japan

Collapse	Year of occurrence	Estimated land-slide volume	Prefecture	River	Construction agency	Construction period: Start	Construction period: Completion
Mt. Bandai landslide	1888	$1{,}200 \times 10^6$ m^3	Fukushima	-	-	-	-
Mt. Tonbi landslide	1858	410×10^6 m^3	Toyama	Joganji River	Toyama Prefecture (later MLIT*)	1906	Ongoing
Mt. Hieda landslide	1911	150×10^6 m^3	Nagano	Urakawa River	MLIT*	1964	Ongoing
Oya landslide	16th century to ca. 1702	120×10^6 m^3	Shizuoka	Abe River	MLIT*	1937	Ongoing
Mt. Mayuyama landslide	1792	110×10^6 m^3	Nagasaki	-	Forestry agency	1916	Ongoing
Osawa landslide (Mt. Fuji)	10th century onward	75×10^6 m^3	Shizuoka	Mt. Fuji Osawa	MLIT*	1969	Ongoing
Kanagi landslide	1746?	8.5×10^6 m^3	Kochi	Sakihama River	Forestry agency	1916	1964

* Ministry of Land, Infrastructure, Transport and Tourism

The Features of the Tateyama Sabo

By comparing Japan's three major landslides (Table 2), we can summarize the features of the Mt.Tonbi landslide and the Tateyama Sabo in context.

- The estimated volume of the Mt.Tonbi landslide was 410×10^6 m^3, which was much larger than the other two landslides.
- Annual precipitation in the basin is 5,000 mm. Tateyama has certainly the world's highest rate of precipitation.
- Debris flow generated by two consecutive breaks of landslide dams formed after the Mt.Tonbi landslide flowed down the Joganji River over 40 km, reached the mouth of the river, and serious damage was caused to many people and property.
- Toyama Prefecture began sabo works in the Tateyama Caldera in 1906, following floods or sediment-related disasters from the Joganji River in 1893, after completion of river modification. In 1926 sabo works were conducted under the direct control of the Ministry. The commencement of this project was more than 30 years earlier than those in other large landslide areas.

Table 2 Overview of Japan's 3 major landslides

		Mt. Tonbi landslide	Mt. Hieda landslide	Oya landslide
Location		Toyama Prefecture	Nagano Prefecture	Shizuoka Prefecture
Basin overview		Yukawa River (Joganji River system)	Urakawa River (Himekawa Rivere system)	Oya River (Abe River system)
	Catchment area	26.0 km^2	22.0 km^2	15.3 km^2
	Length	7.5 km	12.0 km	5.6 km
	Riverbed slope	1/6.4	1/6.0	1/6.0
Annual precipitation		**5,000 mm**	2,800 mm	3,000 mm
Date of occurrence		April 9, 1858	August 8, 1911/April 26, 1912	October 28, 1707
Cause of landslide		Hietsu earthquake	unknown	Hoei earthquake
Estimated landslide volume		**410×10^6 m^3**	150×10^6 m^3	120×10^6 m^3
Damage		**140 deaths, 7,000 victims, 1,600 houses damaged (in 1858).**	23 deaths/missing people, 73 houses damaged (in 1911). 3 deaths, 66 houses damaged (in 1912).	26 deaths (in 1966).
Estimated falling distance		**42.5 km**	9.5 km	4.2 km
Start time of sabo works		1906 (Toyama prefecture) 1926 (Ministry of Home Affairs*)	1964 (Ministry of Construction*)	1937 (Ministry of Home Affairs*)

* now the Ministry of Land, Infrastructure, Transport and Tourism

Conclusion

In Japan, some sabo facilities that were constructed even earlier than the Tateyama Sabo still demonstrates sabo effects; however, the Tateyama Sabo is a typical example of an integrated sabo system that ensures safety downstream of high-risk river reaches. Three representative sabo facilities with different objectives according to form were developed in the 1930s.

These facilities have retained their appearance at the time of construction and continue to demonstrate their original disaster prevention function.

The Tateyama Sabo was designed to integrate technology and practical knowledge to minimize sediment-related disasters. It was built in a harsh, mountainous, natural environment, where construction period term is limited due to snowfall. This extraordinary achievement is worthy of being recognized as an integrated sabo system.

The Dorodani Sabo Dams, Shiraiwa Sabo Dam and Hongu Sabo Dam were deemed highly valuable in terms of technology and history, and designated "Important Cultural Property" of Japan in June 2009 and November 2017.

We hope that the value of the Tateyama Sabo and its effects will be shared throughout the world and handed down to future generations as a precious heritage.

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