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Outline and present of Matsukawa Dam redevelopment project

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Abstract

Matsukawa Dam is a multipurpose dam located in the Matsukawa River, in Iida City, southern part of Nagano Prefecture. It is constructed and managed by Nagano Prefecture. It has implemented flood control in several times since completion of 1975. The upstream of the Matsukawa Dam has been devastated by the Typhoon No.10 in September 1988 and etc. Because of this, there is a large amount of sediment exceeding the planned sediment volume at present. In the Matsukawa Dam, it is necessary to perform preliminary drawdown before flood control. Due to an issue of flood control function, Nagano Prefecture has been working on dam redevelopment projects to restore and improve the flood control function. The contents of this project are to introduce countermeasures to prevent reservoir sedimentation by construction of the sediment bypass facility and to solve complex operation rule with preliminary draw down, and to improve the flood control function by increasing storage volume through sediment excavation. At present, the sediment bypass facility has been completed and its test operation has been started from September 2016. In this paper, we will report the outline and current situation of Matsukawa Dam redevelopment project.

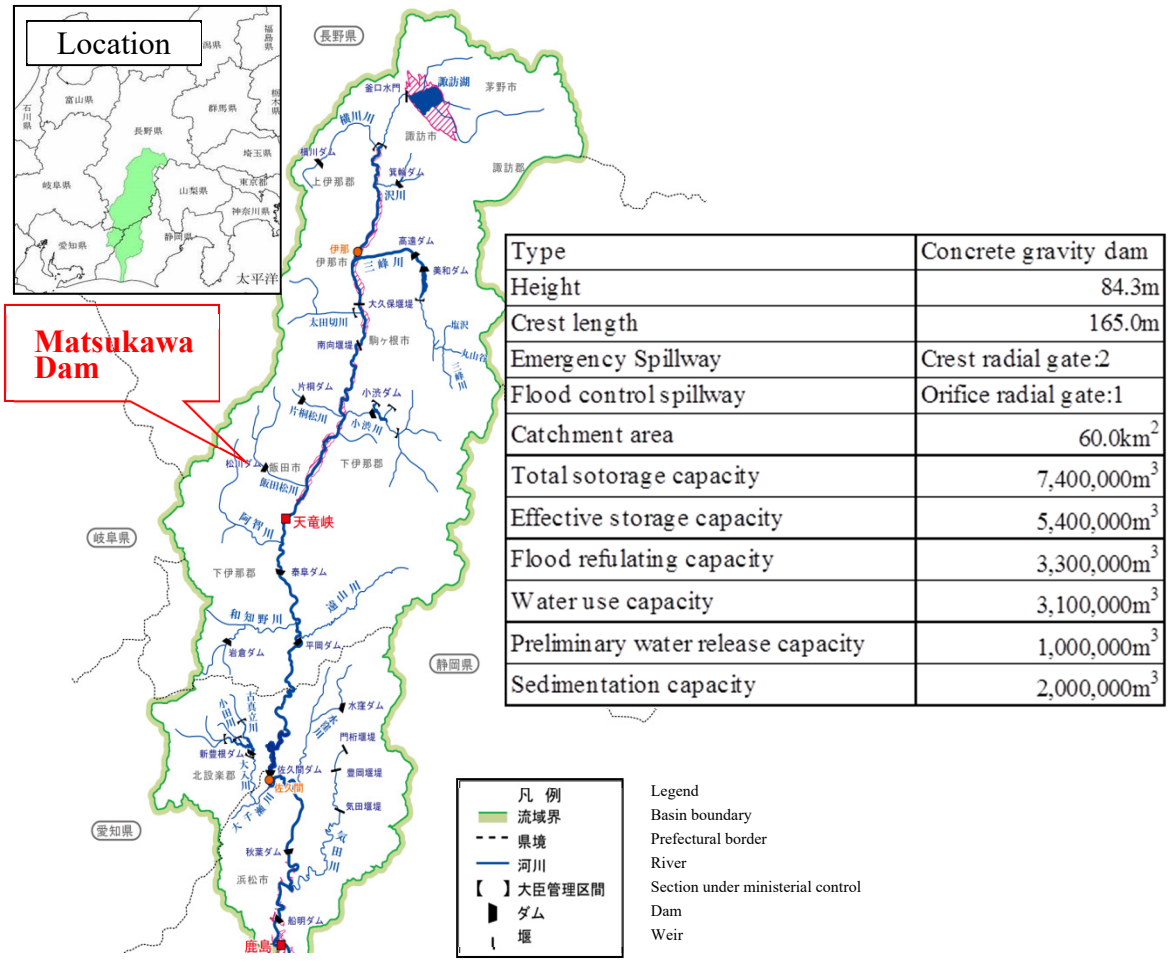
Keywords: Matsukawa Dam redevelopment project, sediment bypass tunnel, excavation

1 Introduction

The Tenryu River originates in Lake Suwa, flows in southern Nagano Prefecture and Shizuoka Prefecture, and finally into the Pacific Ocean. The Tenryu is the class-A river with 213 km long and drainage of 5,090 km^2. Many of its tributaries are rapid streams. The precipitous topography and complicated geological conditions that are generated by the Median Tectonic Line cause active runoff and yield substantial sediment in the area.

The geology in the basin upstream from the Matsukawa Dam is mainly composed of granite of the Ryoke zone, generally known as Inagawa granite. Decomposition progressed in the natural ground along the ridge and numerous landslide scars are distributed in the vicinity. Tributaries in the basin upstream from the reservoir are rapid currents with a mean bed slope of 1/14.

The purposes of Matsukawa Dam are power generation, water supply and flood control. The location and specifications of Matsukawa Dam are shown in Fig. 1.



Type	Concrete gravity dam
Height	84.3m
Crest length	165.0m
Emergency Spillway	Crest radial gate:2
Flood control spillway	Orifice radial gate:1
Catchment area	60.0km^2
Total sotorage capacity	7,400,000m^3
Effective storage capacity	5,400,000m^3
Flood refulating capacity	3,300,000m^3
Water use capacity	3,100,000m^3
Preliminary water release capacity	1,000,000m^3
Sedimentation capacity	2,000,000m^3

Fig. 1: Location and specifications of Matsukawa Dam

2 Sedimentation in the Matsukawa Dam reservoir

In Matsukawa Dam, sediment of 2 million m^3 was planned to accumulate in the reservoir in 100 years. Typhoon No.10 of September 1983 with a two-day precipitation of 352 mm caused inflow of 248 m^3/s, the largest inflow since the completion of the dam. Approximately 480,000 m^3 of sediments, equivalent to one-fourth of the design sedimentation capacity, were deposited in the reservoir by the typhoon. Sediment inflow of approximately 300,000 m^3 and 240,000 m^3 occurred in 1984 and 1985, respectively because of the devastation of the basin triggered by the typhoon in 1983 despite no outstanding floods occurred in these years. In the three-year period between 1983 and 1985, approximately 1,020,000 m^3 of sediments, half of the design sedimentation capacity, were deposited in the reservoir. The amount of sediments in the reservoir reached approximately 2,939,000 m^3, 147% of the design sedimentation capacity, at the end of fiscal 2015. The effective reservoir capacity was reduced to 76% of the initial volume. Fig. 2 shows actual changes in sedimentation in the Matsukawa Dam reservoir since 1974, and Fig. 3 shows the situation of sedimentation in 1983.

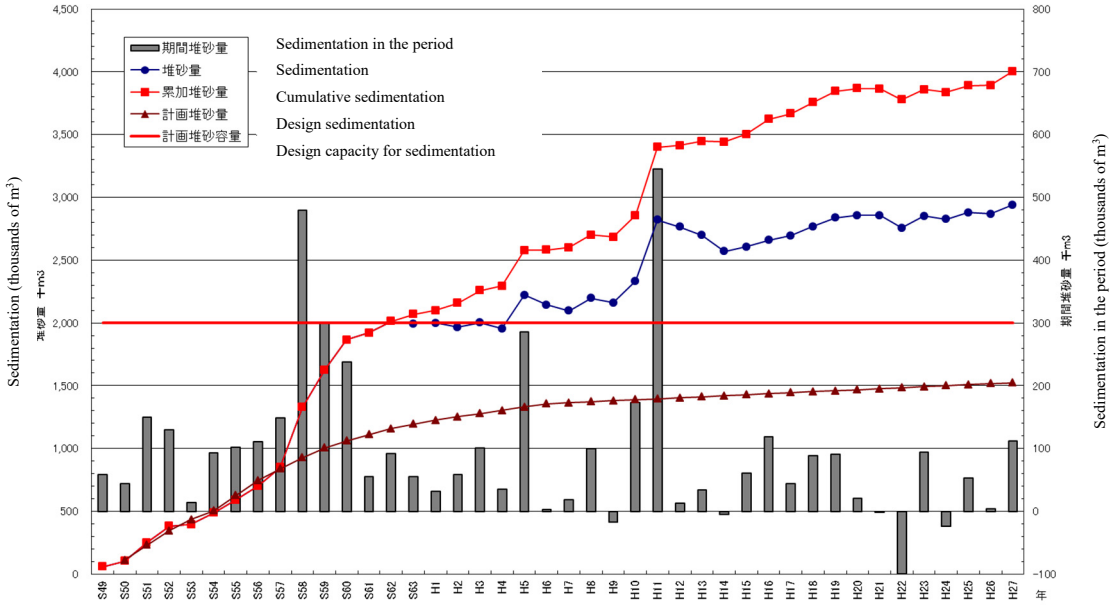


Fig. 2: Sedimentation in Matsukawa Dam

Fig. 3: Extraordinary sedimentation in 1983

3 Redevelopment project

To solve problems described in the previous chapter 2, the prefectural government started discussions on sediment removal plans in 1988. The Matsukawa Dam redevelopment plan was adopted in fiscal 1990 as one of the nationally subsidized flood control dam projects as an emergency flood control measure. The design of bypass facilities was started in 1994, and bypass tunnel construction work was started in 2002 (Hiraiwa 2015). All the facilities were completed at the end of fiscal 2015 and have been operated on a trial basis since September 2016. Fig. 4 shows the arrangements of bypass facilities.

4 Project details

4.1 Bypass facilities operation plan

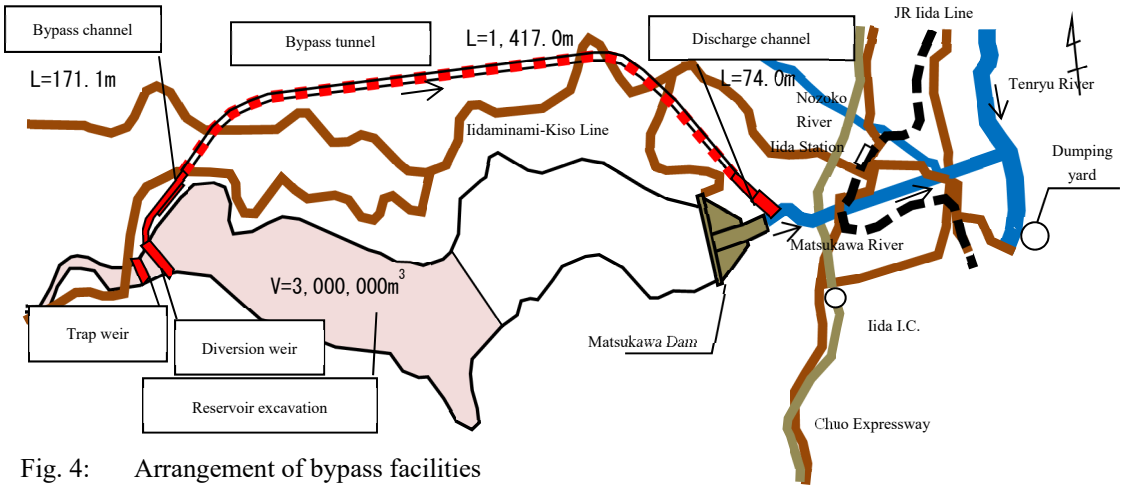


Fig. 4: Arrangement of bypass facilities

The bypass facilities are operated when the flow exceeds 20 m^3/s. It was planned to operate the facilities in coordination with flood regulation at the Matsukawa Dam. Water is bypassed as shown in Fig. 5. Free discharge operation is done when the flow exceeds 170 m^3/s. It was planned to bypass the maximum flow of 200 m^3/s at design high water flow of 440 m^3/s. Fig. 6 shows design high water flow distribution diagram.

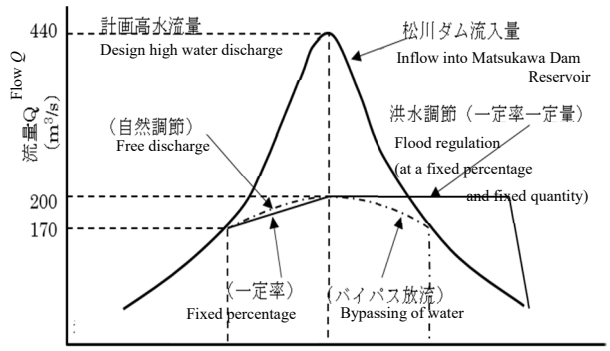


Fig. 5: An example hydrograph of inflow, outflow, and bypassing flow

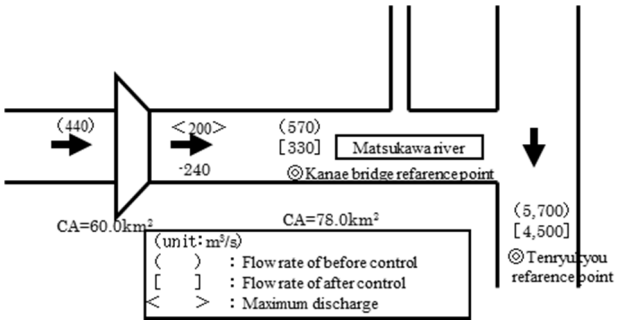


Fig. 6: Design high water flow distribution diagram

4.2 Sediment budget plan

The mean annual sediment inflow at the Matsukawa Dam reservoir was calculated to be 150,000 m^3 according to the actual sedimentation after the completion of the dam and the amount of sediments estimated based on the flood probability.

It was planned that bedload would be caught by the trap weir and diversion weir, which were installed upstream of the reservoir, and 50,000 m^3 of 70,000 m^3 of suspended load and 55,000 m^3 of 60,000 m^3 of wash load would bypass the dam reservoir. That would be the sediment budget at the site.

The current mean annual sedimentation of 141,000 m^3 could be reduced to 5,000 m^3 after the completion of bypass facilities. Fig. 7 shows the sediment budget plan.

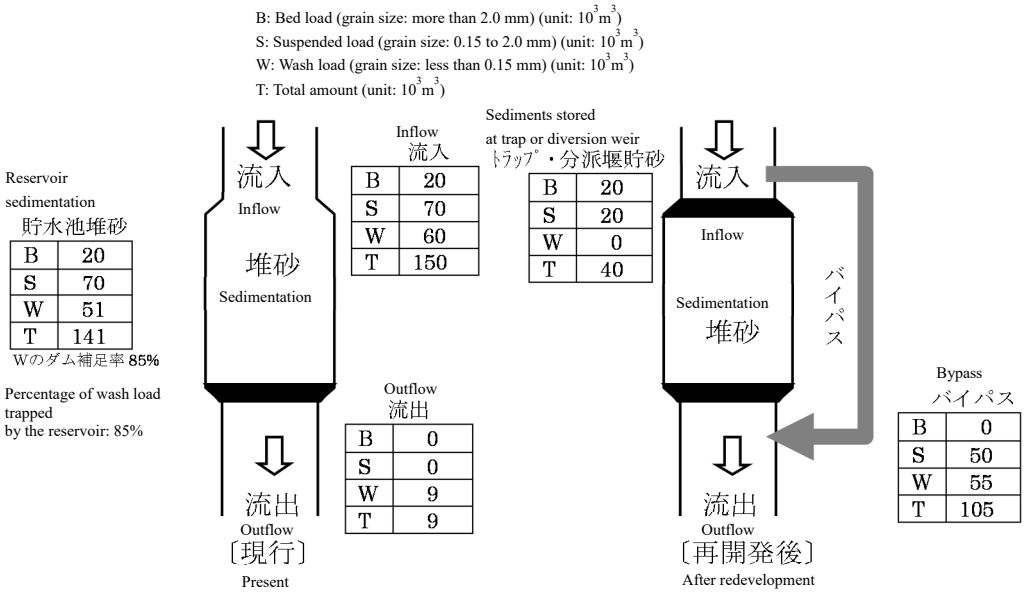


Fig. 7: Sediment budget plan of Maysukawa Dam

5 Outline of bypass facilities

Bypass facilities are composed of trap weir, diversion weir, bypass channel, bypass tunnel and discharge channel. Fig. 8 shows upstream part of bypass facilities.

5.1 Trap weir

The trap weir catches driftwood and coarse sediments from upstream and prevents them from flowing into the diversion weir. Cylindrical driftwood barriers are placed on a steel-framed weir as in Fig. 9a.

5.2 Diversion weir

The diversion weir control the flow and stores sediments. Floodwater that exceeds 170 m^3/s is diverted to the bypass channel and to the overflow of the diversion weir (Fig. 9b).

Coarse grain sediment (bedload) that pass the trap weir are caught and their entry into the bypass tunnel is prevented.

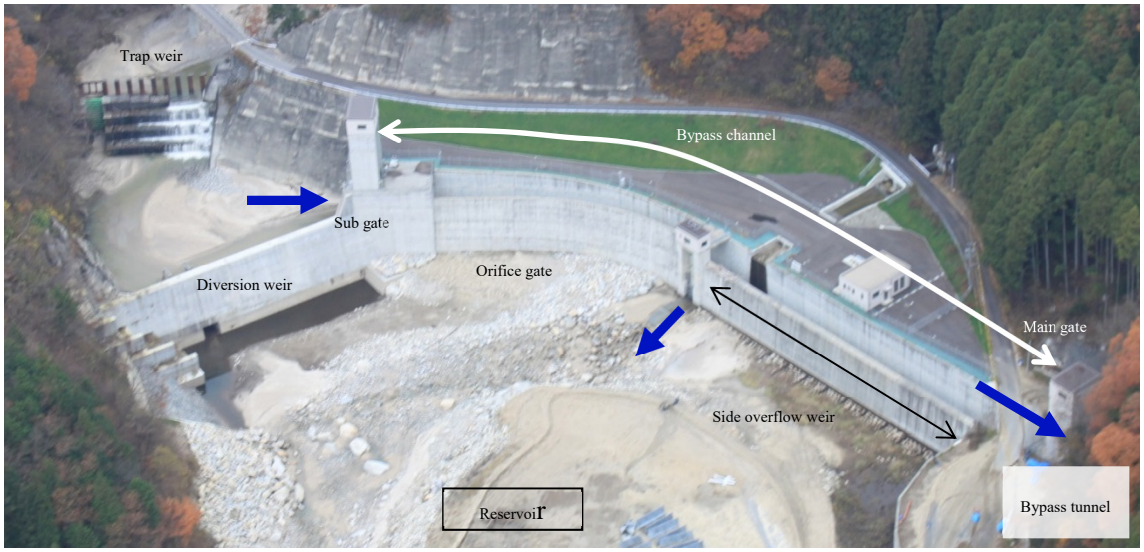


Fig. 8: Bypass facilities (upstream side) of Matsukawa Dam

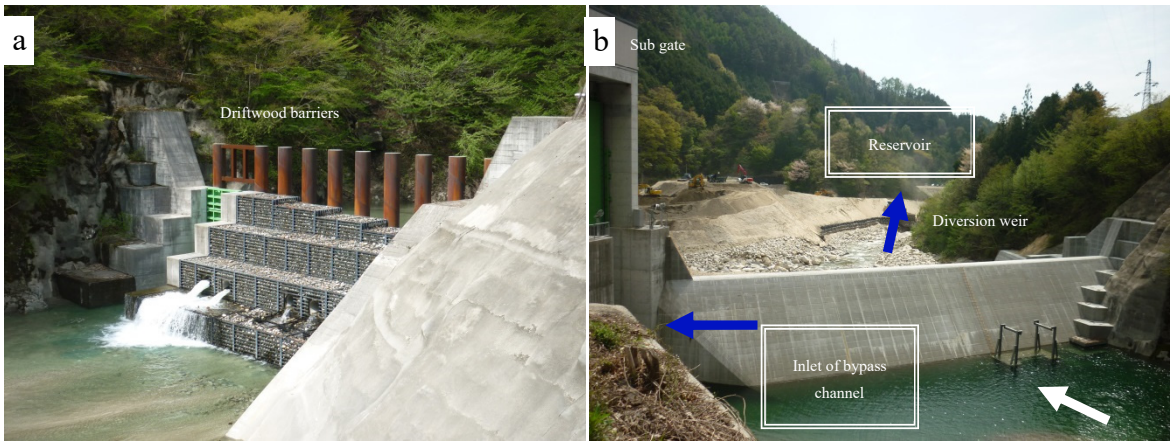


Fig. 9: a) Trap weir (downstream side view), b) diversion weir (upstream side view)

5.3 Bypass channel

The water that flows into the bypass channel is constantly kept by the diversion weir. The inflow less than 20 m^3/s directed into the reservoir via the orifice gate. When the flow exceeds 20 m^3/s at which much wash load is mixed, the orifice gate is closed and the water flows into the bypass tunnel until the maximum flow of 200 m^3/s is reached. Flow more than 170 m^3/s is regulated by the side overflow weir. Fig. 10 provides the profile and plan of the bypass tunnel and the cross section of side overflow weir.

5.4 Bypass tunnel

The bypass tunnel transports suspended-load and washload with water to right-side below Matsukawa Dam. The maximum bypass flow is 200 m^3/s, which is equal to the design maximum flow discharge of the dam.

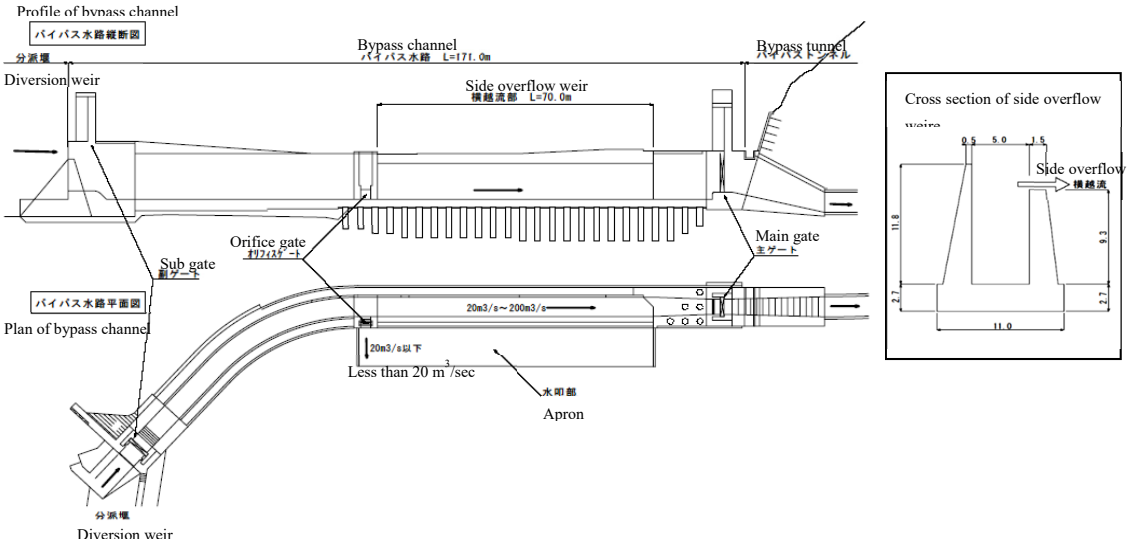


Fig. 10: Profile and plan of bypass channel and side diversion weir

The tunnel spillway has a hood-shaped cross section with a breadth of 5.2 m and a height of 5.2 m. For the invert, 55 cm, the minimum thickness of 35 cm for river water flowing through the tunnel plus the minimum concrete thickness of 20 cm for repair, was secured. The typical tunnel cross section is shown in Fig. 11a.

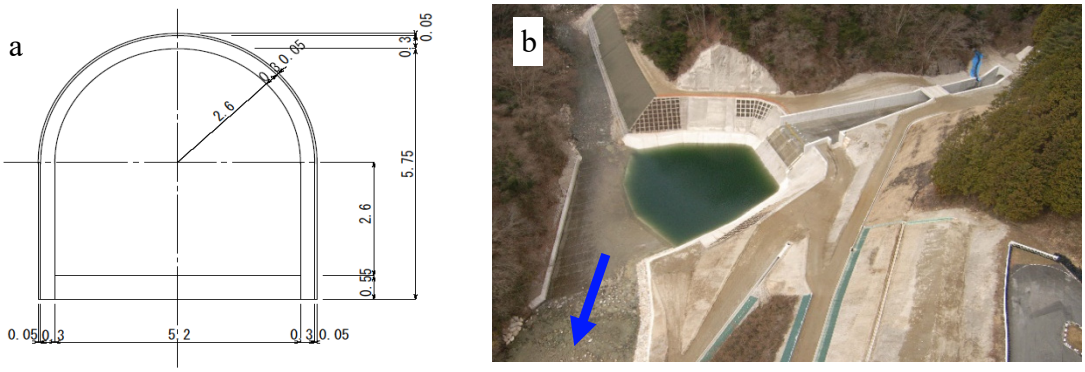


Fig. 11: a) Typical cross section of the tunnel and b) discharge channel

5.5 Discharge channel

The velocity of flow through the bypass tunnel is 15 m/s (tunnel slope: 1/25). The velocity is greatly moderated by increasing the width of the chute. Energy is dissipated by having the waterfall on the river water surface and generate a water cushion while scouring the deposited sediments. Fig. 11b shows the flood discharge channel near tunnel outlet.

6 Present of trial operation

The operation of the bypass facilities was started on a trial basis in September 2016. Trial bypassing was done to confirm the operation on 15th of November (Fig. 12). The maximum bypassed discharge was approximately 7 m^3/s. Safe discharge procedure was examined while monitored the conditions of the bypass facilities and the downstream.

Fig. 12: Trial operation of sediment bypass (at the outlet)

7 Future tasks

Trial operation of bypass facilities has been started and thus a measure has been taken to control sediment inflow. What is left to be done is to remove the sediments currently deposited in the reservoir and solve the problem of complex operation rule with preliminary drawdown.

The effects of sediment runoff due to bypass test operation on downstream river channel need to be identified in future monitoring surveys.

8 Closing remarks

Matsukawa Dam is an important social infrastructure system that protects the city center of Iida City located downstream of the dam from flooding and supplies drinking water to approximately 60% of inhabitants. Appropriate maintenance is important for the functions of the dam facilities to work satisfactorily. The prefectural government, therefore, wishes to respond to the sedimentation issue that it is faced with and to complete the project early.

References

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