

Small hydropower generation using irrigation facilities in Japan

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Introduction

Irrigation facilities have been attracting an attention for installing small hydropower (SHP) due to having unused existing water head. In this paper, we present the typical structure of SHP in Japan and review the characteristics, mechanism and installing cases of SHP at each irrigation facility.

SHP installation on irrigation facilities in Japan

1 Typical structure of irrigation system

Fig. 1 introduces the typical form of irrigation facilities in Japan. In a long length of waterway, many irrigation facilities are constructed, and existing water head is utilized for SHP.

2 Power generation mechanism and characteristics

(1) In river

In order to control the river flow, storage dams and headworks have been constructed in river.

Water head and varied water resources are utilized for SHP (Fig. 2 and Fig. 3).

(2) In irrigation waterway

In irrigation waterway, water head of torrent work, drop work and regulating pond are utilized for SHP. In addition, natural water head occurred from steep topographic is utilized for SHP. The common way of installing facilities is to bypass

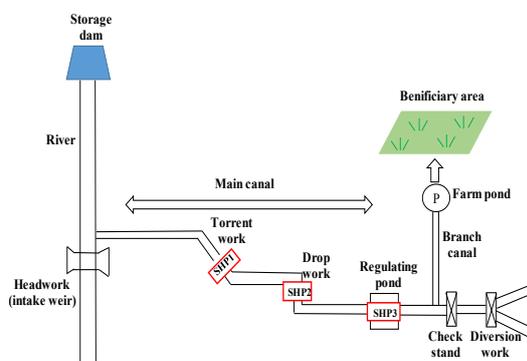


Figure 1 Form of irrigation facilities in Japan

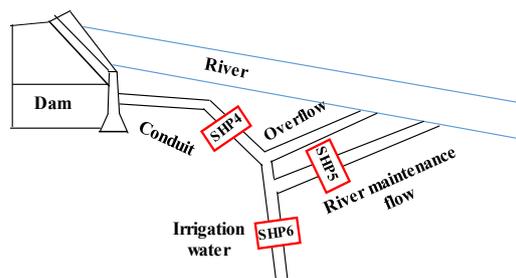


Figure 2 Mechanism in storage dam

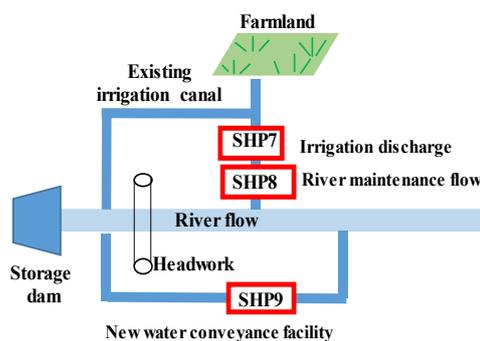


Figure 3 Mechanism of SHP in headwork

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the facilities with pipeline (Fig. 4)

(3) In diversion point

There occurs water head at water diversion point in waterway by weir raising. Diversion work and check stand are considerable points for SHP (Fig. 5)

3. Installing cases

Table 1 summarizes the typical installing cases at irrigation facilities.

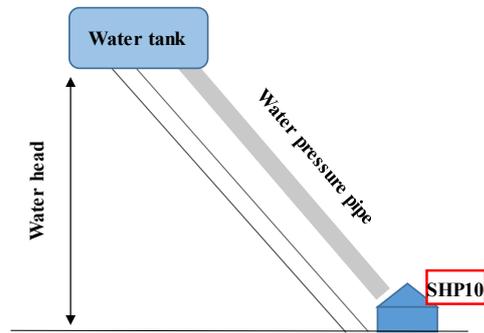


Figure 4 Mechanism of SHP in waterway

Conclusion

There are eight irrigation facilities are reviewed for SHP. Installing mechanism varied according to the different facilities. Installing mechanism is categorized into mainly three types as follows. Firstly, river type of SHP which installs facilities at storage dam and headwork. Many purposes of water resources are flown into the downstream at these two irrigation facilities. SHP at these facilities utilize the different water resources and existing water head to generate electricity. Secondly, waterway type of SHP which installs facilities at torrent work, drop work and regulating pond and natural canal reach. It generally requires bypassing irrigation facilities to obtain the energy and water head.

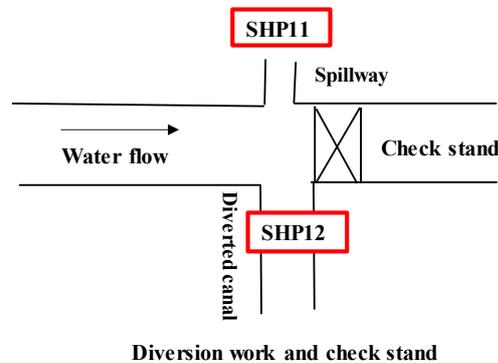


Figure 5 Mechanism of SHP at diversion point

Thirdly, diversion point type which includes SHP at diversion work and check stand. The installing case of check stands type is not developed yet.

Table 1 The typical installing cases at irrigation facilities

Irrigation facilities	Type of power plant	Water resource	Maximum power output (kW)	Effective head (m)	The maximum discharge (m ³ /s)	The annual power generation (MWh)	Water turbine	Reference
Dam	SHP5	river maintenance discharge	49.9	25	0.28	274	Pump Reversing	MAFF, 2020
	SHP6	Irrigation discharge	199	23	1.44	968	Propeller	
	SHP4	river maintenance flow+overflow discharge+irrigation discharge	140	28.2	0.68	750	Propeller	
Headwork	SHP4	river maintenance discharge	520	25.2	2.64	2,570	Francis	MAFF, 2014
	SHP6	Irrigation discharge	1,100	24.1	5.44	7,829	Propeller	Midorinet, 2020
	SHP5	river maintenance discharge	570	10.69	6.5	10,524	Francis	
Bypass canal	SHP10	Irrigation discharge	640	20.7	4	4,060	Francis	MAFF, 2020
Diversion work	SHP12	Irrigation discharge	22	2	5.6	136	Spiral	MAFF, 2020
Drop work	SHP2	Irrigation discharge	197.8	22.8	1.12	652	Francis	J-water, 2020
Torrent work	SHP1	Irrigation discharge	182	6.98	4	495	Cross flow	Aomori-saine, 2020
Regulating pond	SHP3	Irrigation discharge	500	44	1.4	3,163	Francis	Kensetsu-Plaza, 20
Check stand	SHP11	delivery management water	24.7	7.5	0.48	144.5		Wang <i>et al.</i> , 2018