STUDY ON FORMS OF HISTORICAL WEIRS IN JAPAN AS LANDSCAPE ELEMENTS

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Introduction

Weirs are constructed to change the flow of rivers in order to intake water. They are thought to be one of the landscape elements which tell us about the long history of regional lives with the rivers. Karino explains the characteristics of forms of historical weirs[1] as follows [1]. Weirs are not perpendicular but oblique to the river course so that the flow is induced smoothly to the canals (Fig. 1 Left). This expands the area of irrigation, since water can reach farther without loosing momentum at the intake points. It also prevents the weirs from breaking because water pressure to their bodies becomes smaller. The tops of them are kept low in order to reduce the risk of overflows to the hinterlands. Chino and Okuma irradiate the other aspect. Historical weirs are composed with natural materials such as stones and woods because modern materials such as concrete were not available in those days [2]. Therefore, it is assumed that the weirs create the sort of landscape that water runs gently over the body of stone weir lying low in the river at an angle (Fig. 1 Right).

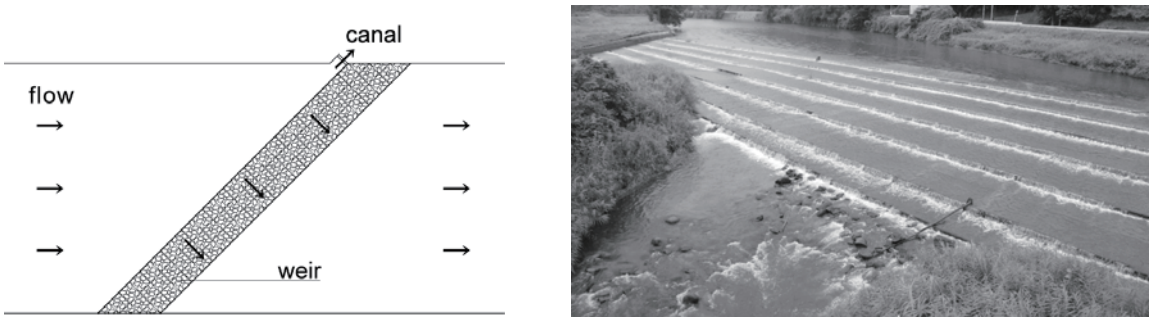

Fig. 1: Traditional forms of historical weirs

Left: Diagram implied by precedent studies
Right: Example of historical weirs (Ogawa-esuji weir, the Natsui River, Fukushima)

However, it is anticipated that changes have arisen in such traditional forms today. Before modernization, difficulties of repair were troubling people whenever the weirs were damaged by floods. It is thought that such vulnerable materials and structures have been transposed to more solid and durable ones by modern technology, which is represented by concrete. The issue what kinds of change have occurred in the traditional forms is raised. Iwaya mentions that 239 oblique weirs have been existing or existed once in 78 domestic river basins [3]. Thus, the objective of this research is to clarify the characteristics of forms of existing examples of these oblique weirs [2].

Methods

With reference to the research of Iwaya, 167 examples of the oblique weirs which have been confirmed to still exist in 73 river basins are investigated (Fig. 2). 78% of them are located in the western part of Japan including the districts of Kinki, Chugoku, Shikoku and Kyushu. The tendency of the west unbalance distribution is also pointed out by Iwaya. There is no example preserved as cultural asset.

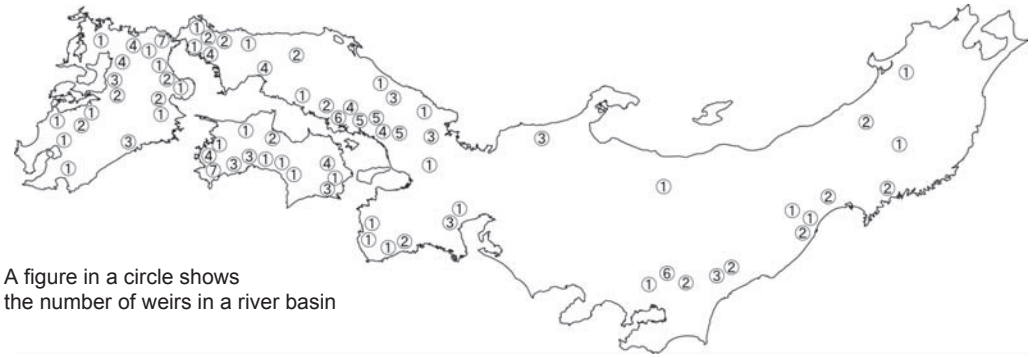

Fig. 2: Map of existing oblique weirs in Japan

It is assumed that the forms of those oblique weirs could change in the following ways. First, the section may have changed from the board-like form to the trapezoid. The trapezoid section which has a steep slope with a horizontal apron followed is the standard form in the design of modern weirs [4]. Next, the material of the weir bodies must have changed from stone and wood to concrete. Furthermore, a mechanical flushing gate may be equipped.

On-site survey was carried out from 2008 through 2011. The contents of investigation are measure of length, width and slope, record of both sectional form and material of the weir bodies, and check of the existence of mechanical flushing gates.

Results

The length of the weir bodies takes the value from 27m to 840m, and average value is 132m. Meanwhile, the width of the weir bodies takes the value from 1m to 71m, and average value is 14m. The scatter diagram shows the combination of length and width (Fig. 3). No specific tendency about the combination of length and width is recognized.

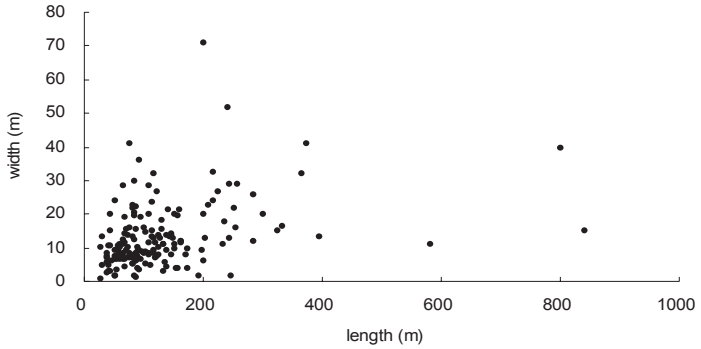

Fig. 3: Scatter diagram of weir sizes, length and width

There are three types of sections, which are trapezoid, board-like and step-like shapes. The board is the shape that the whole surface is a loose slope or a flat. Comparing the average of slopes between the shapes, the board is 11% to the trapezoid being 94%. The step is the shape that the level surfaces of different height continue. The bar graph shows the rate of the three shapes (Fig. 4). It turns out that nearly a half of the oblique weirs are trapezoids (Fig. 5).

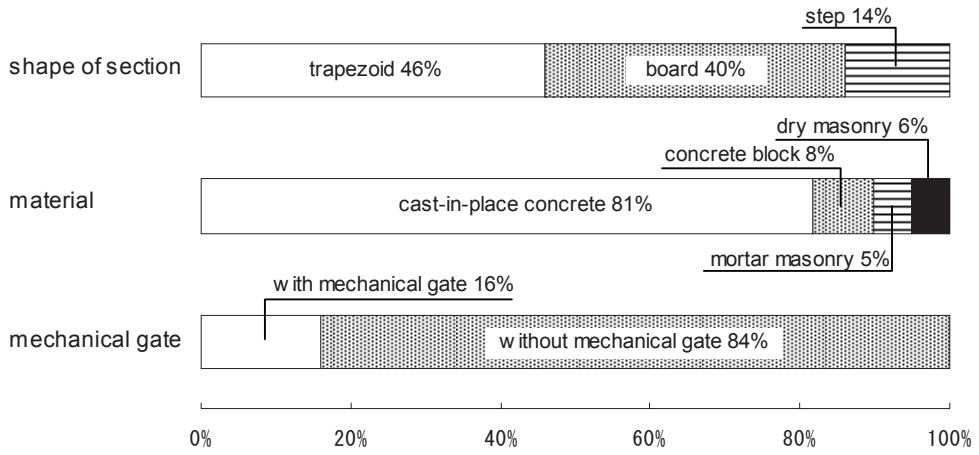

Fig. 4: Bar charts of shape of section, material of weir body, mechanical gate

Fig. 5: Example of trapezoid shape (Kusuriya-weir, the Kuji River, Ibaraki)

In the case of material, 81% of the weir bodies are composed with cast-in place concrete, 8% with concrete block, 5% with mortar masonry and 6% with dry masonry (Fig. 4, 6, 7).

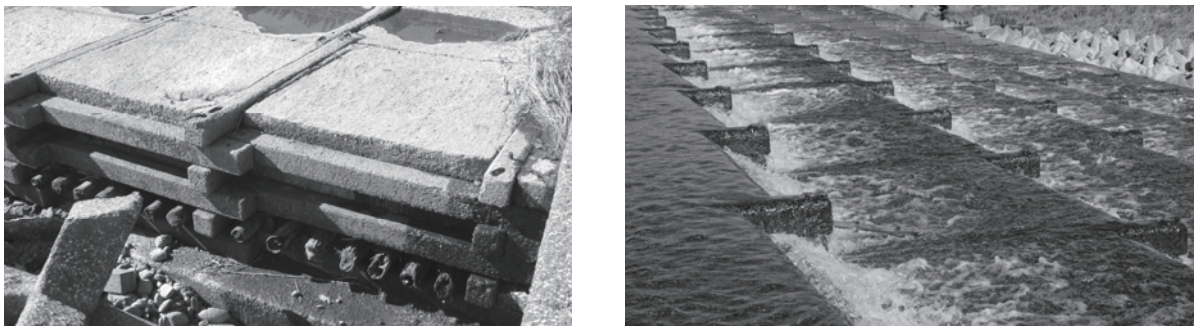

Fig. 6: Example of material, concrete block (Tajimaya-weir, the Arakawa, Saitama)

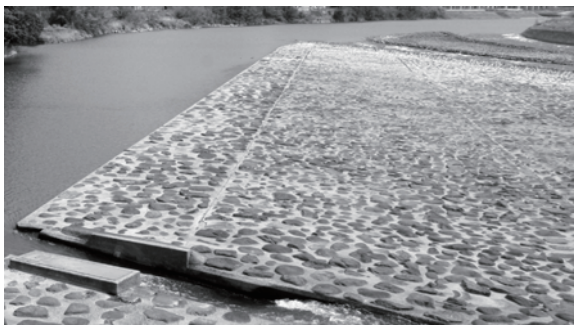


Fig. 7: Examples of material
Left: Mortar masonry (Yamada-weir, the Chikugo River, Fukuoka)
Right: Dry masonry (Daiju-weir, the Yoshino River, Tokushima)

In the case of flushing facility, 16% of the weirs are equipped with one or more mechanical gates (Fig. 4, 8). The remaining 84% are operated by people's hand mainly with sheathing boards.

Fig. 8: Example of mechanical flushing gate (Hata-weir, the Niyodo River, Kochi)

Discussions

The typology of the weirs is derived from the result that the weirs have been classified according to the combination of shape of section, material and mechanical gate (Fig. 9). All the weirs of trapezoid section are composed with cast-in-concrete. These weirs, which account almost half of the whole, create the sort of riparian landscape different from the original, mainly because of their much steeper slopes. Moreover, quarters of them are equipped with the mechanical gates.

Conversely, both board and step weirs still keep the landscape that water runs gently over the bodies lying low in the rivers diagonally. But there are few differences of appearance of water among them as to materials and ways of placement. In the case of board, more than 70% of weirs are in cast-in-concrete, but only three of them in concrete block. The remainder is masonry and the ratio of wet and dry is half-and-half. In the case of step, there is almost no masonry while cast-in-concrete and concrete block are divided mutually into the same number. Even if the weirs of both board and step sections are composed with concrete, there are few examples equipped with mechanical gates.

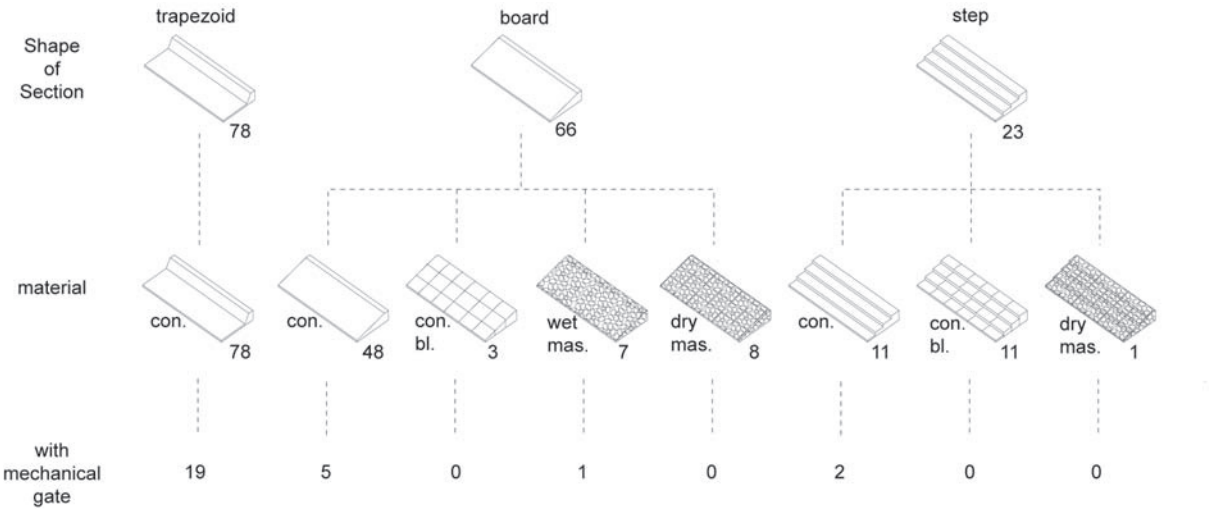

Fig. 9: Typology of oblique weirs according to the results

A figure under a weir shows the number of its type.
con. : cast-in-concrete, con. bl. : concrete block, wet mas. : wet masonry, dry mas. : dry masonry

It is thought that traditional forms remain completely in the weirs of board and step with dry masonry, but such weirs are only 5% of the whole. Although there is not so much difference in masonry between wet and dry with the point that stones cover their surfaces, there is a great difference at the point of whether water penetrates the weir bodies. In addition, there is a difference of technique because high level of skill is needed for stacking stones in dry masonry.

90% of the whole are made from concrete and seem to be modern products. However, if looking carefully, there are also forms considered to be traditional succession. To fix concrete blocks by frames is a modern version of the traditional construction method which stuffed stones into wooden frames. The frames which fix blocks are made from wood, concrete and steel.

Conclusions

As mentioned above, it is a trend that historical weirs are altered to the trapezoid in cast-in-concrete equipped with mechanical gates, and only being oblique to the flow of river is inheriting the conventional form as the original riparian landscape elements. However, though there are few numbers, the weirs which have inherited the traditional forms by shape of section, material, and flushing gate operated by human power still exist. It is important to clarify the factors in which the historical weirs have remained without designation as the cultural assets and to explore the methods of preservation and succession of them.

Notes

1. The term of historical weir refers what was initially constructed before the modern times.

2. Iwaya classified the weirs according to the plane forms in terms of river technology, but not evaluated those as landscape elements.

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