Formation of Waterside Spaces with Groins

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Synopsis

River management in recent years involves measures for waterside management emphasizing the environment and utilization as well as river improvement and irrigation. This study addresses the formation of waterside spaces with groins as a part of waterside management emphasizing the environment and utilization, using typical groin management cases in which planning we have been engaged. This report presents our knowledge obtained through processes from planning, business implementation, and subsequent degradation by aging.

KEYWORDS: River environment, waterside space, waterside management, groin, land–water ecotone

1. Study Background and Objectives

Groins in Japan have been used from ancient times to control streams and mainly to protect riverbanks from flooding. Groins have been used for securing water transportation routes in modern times since Meiji, represented by Krippen groins constructed by Dutch engineer Johannis de Rijke. River management in recent years involves measurements for waterside management focusing on environment and utilization as well as river improvement and irrigation. Diverse streams generated by groins have contributed to flood control and to the rehabilitation and creation of excellent river environments.

This study addresses effective planning and maintenance management methods for the formation of a waterside spaces with groins as a part of waterside management, with emphasis on environment and utilization, using three typical groin management cases in which planning we have been engaged. Using them as examples, we share our knowledge obtained through processes related to planning, business implementation, and subsequent aging degradation.

2. Tasks in Groin Management Areas

Tasks in the following three areas of waterside management have been promoted by application of groins.

2.1 Case 1: Kizugawa Waterside Plaza [1)]

The Waterside Plaza was constructed for environmental learning integrated with protected lowland facilities in the neighborhood of the Nagarebashi Bridge, downstream of the Kizugawa River of the class-A Yodogawa River system. The emergence of river banks and loss of land–water ecotones had been advancing by the development of an ultra-low water channel (Fig. 1). The task was to rehabilitate sand river beaches (large-scale sandbars) that used to be there.

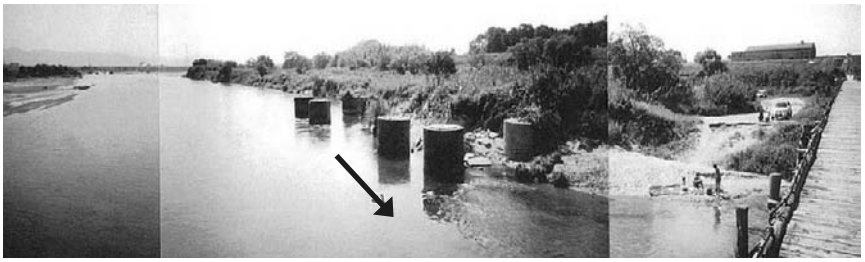

Fig. 1 View before construction (Case 1).

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2.2 Case 2: Kizugawa Kasagi area [2)]

This area is located upstream of the Kizugawa River of the class-A Yodogawa River system, at the foot of Mt. Kasagi, which is designated as a historic site and beauty spot of Japan. The site has been used by a neighboring elementary school for canoe school lessons and fieldwork related to water quality as part of environmental education. Development has been in progress for its use as a "Waterfront Fun School."

A waterside environment that provides safety and environment in harmony is necessary for multi-purpose usage patterns such as water wildlife observation and canoeing. However, this site had lost a sandbar that once existed there (Fig. 2). Therefore, it was required that a gentle waterside environment (land–water ecotone) be created, which would not spoil the landscape but which would secure safety at the time of canoe boarding or wildlife observation at the waterside.

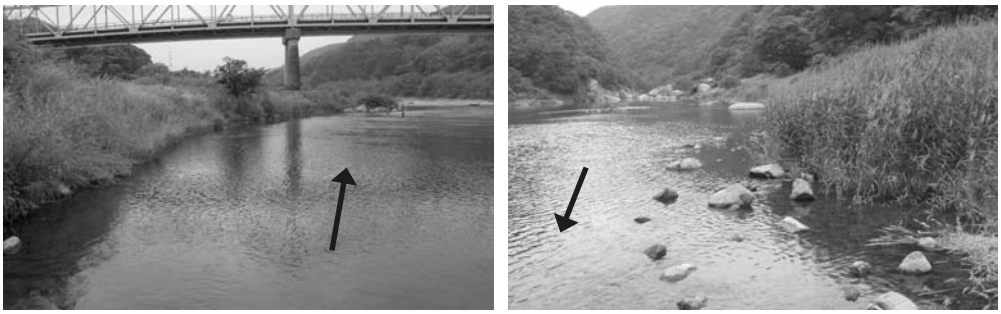

Fig. 2 View before construction (Case 2).

2.3 Case 3: The Yoshiminegawa River, Kyoto [3)]

Nature-friendly river works were advanced on the Yoshiminegawa River of the class-A Yodogawa River system. At the river bend (Fig. 3), which is a planning site, establishment of a land–water ecotone was advanced for creating waterside utilization or a habitat of a good ecosystem on the inner bank. At the same time, policies for protecting river banks were required while creating deep water in the water colliding front incorporated with low-water bed works by crosspiece structures on the upper and lower streams.

Fig. 3 View before construction (Case 3).

3. Measures with Groins and Aging Degradation after Construction

3.1 Measures with groins

Groin construction was conducted as described below, according to the tasks of each construction area. Table 1 presents project details for each area.

1) Case 1: Kizugawa Waterside Plaza

Plans were made to reclaim a large-scale sandbar with the combination of diverse structures comprising five sets of impermeable and permeable groins. Specifically, three short impermeable low-water groins were positioned at the uppermost stream aiming at changing flow direction, and one permeable low-water groin for building up a varied sandbar and one impermeable low-water groin for forming a reliable sandbar were installed downstream.

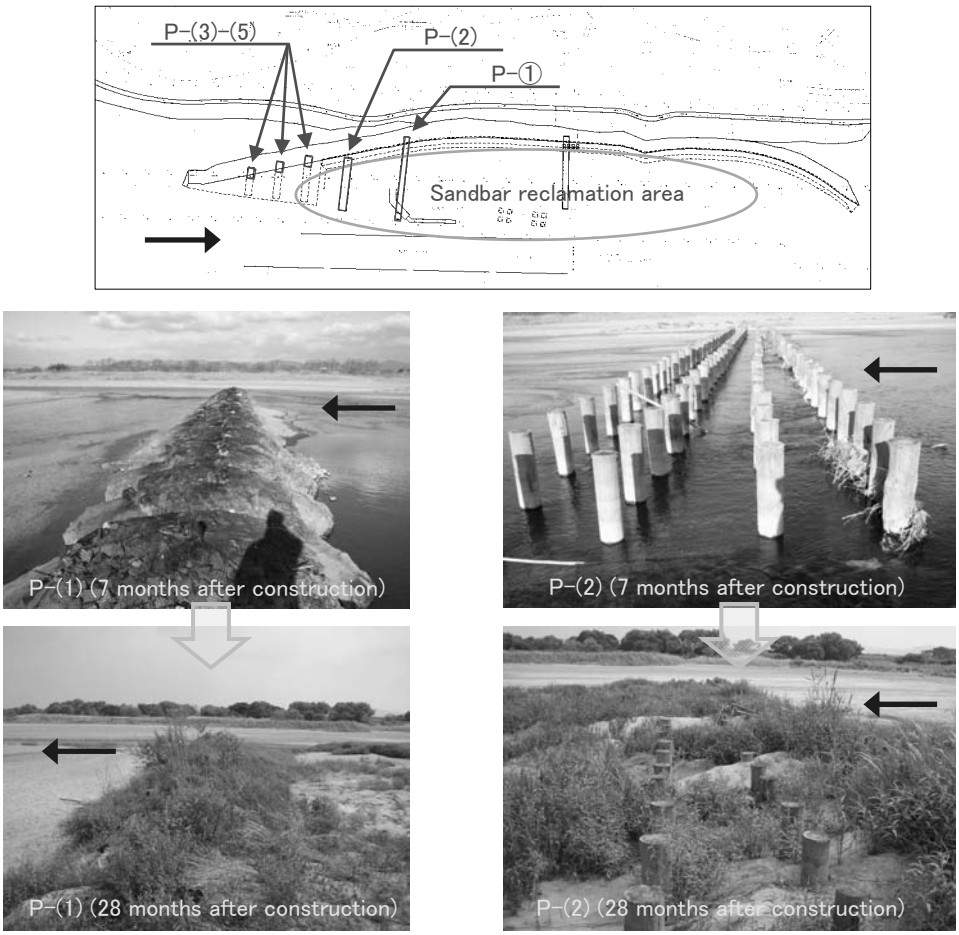

Fig. 4 Project outline and aspect after construction (Case 1).

Table 1 Detailed groin plan in each case

Area name	Kizugawa Waterside Plaza (Case 1)			Kizugawa Kasagi area (Case 2)	Yoshiminegawa River, Kyoto (Case 3)
River name and river system	Kizugawa River, the Class-A Yodogawa River system			Kizugawa River, Class-A Yodogawa River system	Yoshiminegawa River, Class-A Yodogawa River system
Estimated high-water discharge	6,200 m^3/s			6,200 m^3/s	160 m^3/s
Estimated high-water inclination	1/1300			1/220	1/125
Segment	Segment 2-1			Segment M	Segment 1
Groin number	P-(1)	P-(2)	P-(3)–(5)	K-(1) - (3)	Y- (1)–(4)
Groin type	impermeable low water groin (overflow groin)	permeable low water groin	impermeable low water groin (overflow groin)	impermeable low water groin (overflow groin)	impermeable low water groin (overflow groin)
Groin structure detail	Bagged cobbles	Pile dike + bagged cobbles	Bagged cobbles	Stone-Net™	Natural stone joint structure
Objective of installation	Sandbar formation	Sandbar formation	Hydraulic jump	Sandbar formation	Deep water formation, river bank protection
Number of groins	1 (lowermost stream)	1 (middle)	3 (uppermost stream)	3	4
Installation angle	85°, inclined	85°, inclined	85°, inclined	75°, inclined	70°, inclined
Groin crown height	low-water level + 0.5 m (+1.6 m of river bed)	low-water level + 0.5 m (+1.7 m of river bed)	low-water level + 0.5 m (+1.7 m of river bed)	ordinary water level (+0.5 - 1.0 m of river bed)	ordinary water level (river bed elevation)
Groin length (ratio to ordinary river width)	74.5 m (1/4.3)	47.9 m (1/6.7)	9.6 m (1/33.3)	10.0 m (1/10)	2.0 m (foot protection width)
Year of construction	FY 2005	FY 2005	FY 2005	FY 2010	FY 2009

2) Case 2: Kizugawa Kasagi area

It was planned in this area to install groins as a necessary minimum reversible artifact harmonized with the landscape. Their environmental effects were to be used to reclaim the original scenery of this area (sandbar). Then it was intended to recover a waterside environment securing safety and environmental diversity. Specifically, it was scheduled to place three impermeable groins to encourage the formation of a small-scale sandbar for river utilization immediately downstream of the groin.

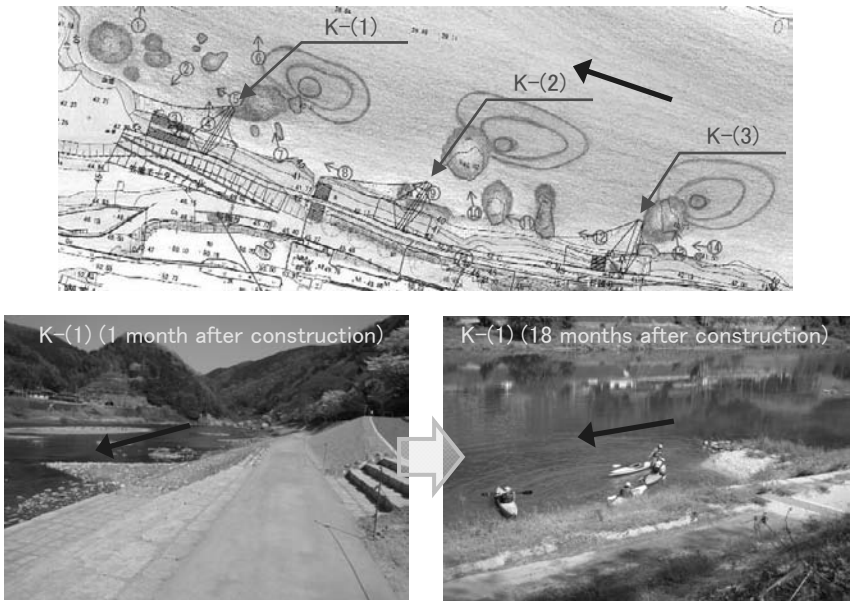

Fig. 5 Program outline and aspect after construction (case 2).

3) Case 3: Yoshiminegawa River, Kyoto

The project included the installation of four sets of short impermeable groins at a water collision front, and encouraged the creation and sustainment of a deep water area by the scouring effect of groin edges. It was anticipated that deep water areas created by this formation would induce an ordinary water route to the water colliding front, which contributes also to sustainment of a land–water ecotone on the opposite bank.

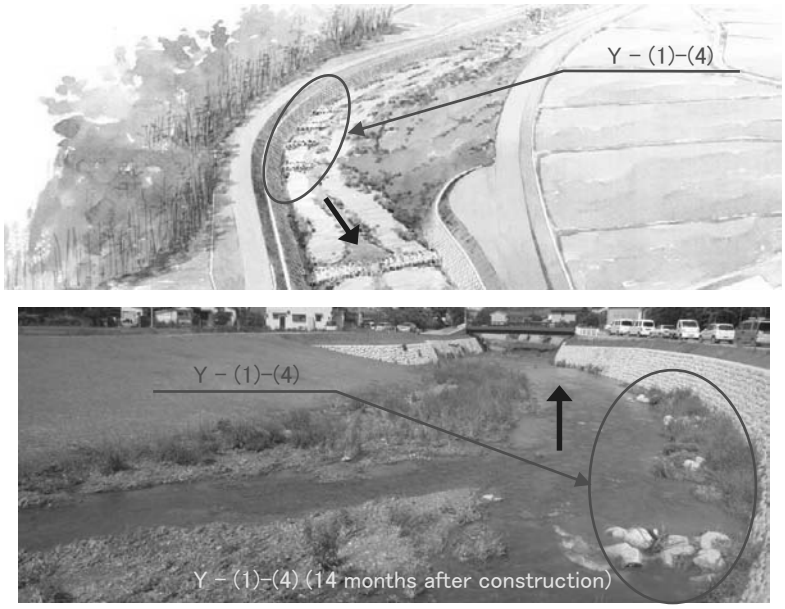

Fig. 6 Construction rendering and aspect after construction (case 3).

3.2 Aging degradation after groin construction

In response to the tracking result of aging degradation of groins after construction, the circumstances from construction to the present are organized, from the viewpoints of (a) environmental, (b) utilization, and (c) river improvement aspects.

1) Case 1: Kizugawa Waterside Plaza

(a) Environmental aspect

A large-scale sandbar was formed between groins P-(1) and P-(2) and downstream therefrom, where sandbar formation had been expected, within half a year after groin installation. The sedimentation trend has been sustained since. A sandbar of about +1.0 – 2.0 m high above the groin installation level is stable today.

Regarding the sandbar formation effect by groins, the sedimentation effect of an impermeable groin (P-(1)) developed more quickly than with a permeable groin (P-(2)). However, a more complex sandbar was formed by a permeable groin. Rooting of herbs has progressed on sand accumulated up to near the crown of groins. Willows have flourished since about five years after installation.

As for the banks, although emergence of the low water channel was remarkable by division from the water area before construction, the regeneration of waterside vegetation such as *Phragmites japonica* is observed today.

(b) Utilization aspect

Because the steep banks, deep water, and fast stream were considered dangerous, almost no river users ventured around the waterside or water area before construction. However, since a sandbar was formed after construction, children have come to play in the water, people stroll on the sandbar, and tourists visiting to the water's edge have become a common sight.

(c) River improvement aspect

Because groins P-(1) and P-(2) were constructed as inclined, aiming at sedimentation, only their edges showed a prominent scouring effect, although scouring has been observed that causes modification on a revetment foundation. Groins P-(3)–(5) were also built as inclined, but groins of the minimum length as much as foot protection width have allowed the effects of a scouring section at the groin edge to extend near the bank (revetment foundation protection). This has modified the revetment slightly, but no particular problem has been reported to date because this is a revetment of gentle slope with high flexibility made of bag bodies. Moreover, the scouring is within the range of the maximum depth.

2) Case 2: Kizugawa Kasagi area

(a) Environmental aspect

A sandbar was formed downstream from groins K-(1)–(3), where sandbar formation was intended, within half a year after groin installation, and a sandbar of about + 1.0 m high above the river bed elevation is stable at present. Herb rooting has been observed only on the groin crowns above ordinary water since around half a year after groin construction. Nevertheless, no trees have grown there yet.

As for the river bank situation, although the water depth had reached nearly one meter from the waterside immediately before construction, a land–water ecotone has been created by a sandbar. It is sustained today.

(b) Utilization aspect

Steep banks and deep water were regarded as dangerous before construction. However, canoe school lessons have been held safely since the sandbar was formed.

(c) River improvement aspect

Although all three sets were planned originally to be rockwork groins covered by natural stone anchored to wire gauze (Stone-Net™) in the planning phase, it was found that a rockwork groin of natural stones had been installed instead on the uppermost stream at the time of construction. Its stone-only structure permitted stones to be washed away within half a year after construction. Nevertheless, no noticeable damage occurred in the remaining two rockwork groins covered by Stone-Net™ even today, more than three years after construction.

Only the groin edges showed a prominent scouring effect, although no scouring was observed to cause modification on the revetment foundation.

3) Case 3: The Yoshiminegawa River, Kyoto

(a) Environmental aspect

The scouring trend of edges has been sustained at all groins Y-(1)–(4), so that deep water of about - 1.0 m depth from the groin installation level is stable today, three and a half years after installation. This stability leads an ordinary water route to the water colliding front side. Therefore, it contributes to sustainment of a land–water ecotone on the inner bank. Sedimentation effects are evident downstream of groins, except for one set on the uppermost stream, in spite of the minimum groin lengths of as much as the foot protection width.

Moreover, since the groin crown height was set as high as designed river bed level, the groins had been supposed to be underwater a full year so that no herb rooting had been anticipated. However as deep water formed and the ordinary water level was lowered more than assumed, herbs have taken root on the groin crown and on the sandbar between groins, which have not resulted in tree growth causing river flow impediment.

(b) Utilization aspect

Steep banks made the waterside almost inaccessible before construction. However, waterside utilization by community residents has become popular by access via the land–water ecotone on the inner bank after construction.

(c) River improvement aspect

Inclined groins aiming at creation and sustainment of deep water areas by scouring at groin edges have produced a prominent scouring trend around the edges. A groin length as short as the minimum foot protection width had raised concerns that the effect of the scouring section at the groin edge would extend to the revetment foundation protection (near the bank). However, the revetment foundation protection of groins (revetment embedment) was in a sedimentation trend except for one set on the uppermost stream, so that no damage such as modification of revetment by excessive scouring has been observed.

4. Important Matters in Evaluation, Planning, and Maintenance Management of Groins in Waterside Space Forming

The effect of groins for waterside space formation is evaluated based on measures with groins and their aging degradation after construction in the three areas. Points of discussion include important matters from the viewpoint of the structure type and scale in the planning phase, and tasks and important matters in maintenance management.

4.1 Groin type

Comparison in the identical area (Case 1) revealed that an impermeable groin shows a greater sedimentation effect than a permeable groin, and that the latter forms a more complex sandbar than the former, so that the latter improves waterside diversity to a greater degree. However, herb rooting on a sandbar deposited up to near the crown (picket top) allows a permeable groin to hold earth and sand even at a flood. Therefore, it was verified that a permeable groin tends to be an impermeable groin not only in terms of geometry but in terms of its effects.

The structure of a permeable groin projected from the river bed tends to catch down-flowing objects, which might not be preferred on a landscape, so that maintenance management is necessary, including removal. Because they also might threaten the safety of facilities at a flood, it is necessary to perform sufficient examination in consideration of the collision of flowing-down objects and load at the time of complete occlusion, as well as fluid force by a stream, at the planning phase.

4.2 Groin length

It was verified that the groin length was about 1/10 of ordinary river width as Cases 1 and 2, which suffices for forming a land–water ecotone by sufficient sandbar sedimentation effects.

Concerns arose that the minimum groin length as long as a foot protection width as Case 3 can hardly

anticipate sedimentation effects because the scouring effect of groin edges extends to the river bank. Nevertheless, sandbar formation by sedimentation has been confirmed near the river bank even by the minimum length of groins. In other words, a groin as long as the foot protection width can promote the formation and sustainment of deep water and river bank protection at a water collision front simultaneously.

4.3 Groin height

Standard practices give an upward inclination of about 1/10 toward the river bank side so that a groin edge becomes at ordinary water-level elevation. Planning was carried out based on this in Cases 1 and 2, aimed at formation of a land–water ecotone by the sandbar sedimentation effect. Results confirmed sufficient sandbar formation effects.

However, because groins are above the ordinary water level, herb rooting proceeds. Trees such as willows flourish. Because these results raise fears that fallen trees might damage groins during a flood, maintenance management such as cutting trees is also necessary. It is important to plan projects related to sandbar formation effects and emergence of groin crowns in a tradeoff relation, while taking care of maintenance management.

When aiming at the formation and sustainment of deep water, it is necessary to suppress sedimentation near a groin and to suppress the emergence of groin crowns that impede derivation of a water route. Therefore, it is effective to make the groin height as high as the river bed level, as was done in Case 3.

4.4 Constituent materials

Groins have been made from stone and wood from ancient times. Rockwork in an impermeable groin and stone packing to a wooden mattress for foot protection in a pile groin require skillful workmanship. Although no change in using a lot of stone or wood has occurred even today, it has become possible to secure the required performance without any skillful workmanship using techniques such as bagged cobbles, Stone-Net™, and a natural stone joint structure used in Cases 1–3. Therefore, it is necessary to use such new technologies actively.

5. Conclusion

Documentation by the Kyushu and Tohoku Regional Development Bureaus compiled based on experiences to date are useful in groin planning. Practically, there are many projects planned in reference to these even in Kansai district. However, factors surrounding groin planning such as the flow regime, bed materials, and vegetation situation of a river vary among areas. Their effects cannot be compiled uniformly into documentation, but an analytical method of groins suitable for the area must be applied.

This study has evaluated the formation of a waterside space with groins using typical groin management cases we have planned. Using them as examples, based on our knowledge obtained through the processes from planning, business implementation, and to subsequent aging degradation, we have proposed important matters related to planning and maintenance management. It is expected to be necessary in the future to conduct analyses and evaluation of the effect and tasks of groins based on the case of each area, and to establish an effective method for the planning phase or maintenance management.

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