IMPROVING WIRE NET DAMS AND CAPTURING RESULTS

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INTRODUCTION

In the early 1970s, a wire net dam was first constructed on a trial basis for capturing a debris flow. The wire net dam was subjected to the actions of several debris flows, and more than one hanger rope broke, resulting in an outflow of captured sediment. Subsequently, a dam having a steel pipe frame structure was developed, which became the mainstream of open steel Sabo dams.

However, a wire net dam can be erected without disturbing the riverbed and with ease, so it has excellent environmental performance and superior safety performance by reducing dangerous work in a riverbed where debris flows. As a result, this type of dam has come to be highly evaluated in recent years. Therefore, we have developed an improved wire net dam based on our experience, and 2 units have been constructed on a trial basis. Furthermore, one of the 2 units has already captured a debris flow. This report describes the development of the improved wire net dam, as well as the results of capturing debris flows.

1. Development of improved wire net dam

Fig. 1 shows front views of the conventional wire net dam and the improved wire net dam, and **Fig. 2** shows side views. A wire net dam aims to dissipate the energy of a debris flow or to capture it by means of a net, and to transmit its load in the order of the

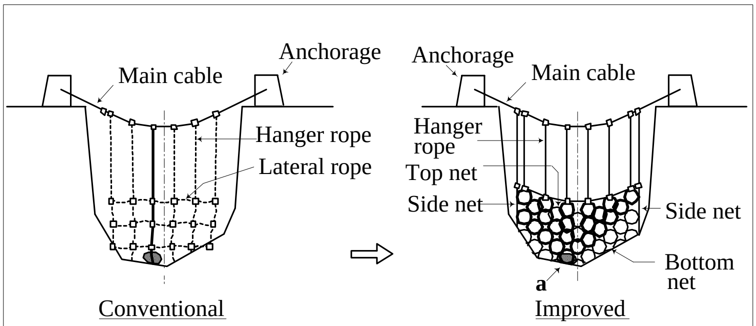

Fig.1：Front view of wire net dams

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hanger rope → main cable → anchorage. Accordingly, a large load is concentrated on the anchorage.
To respond to structural problems associated with the conventional wire net dam, we have come up with various inventive ideas as shown below to develop an improved wire net dam.

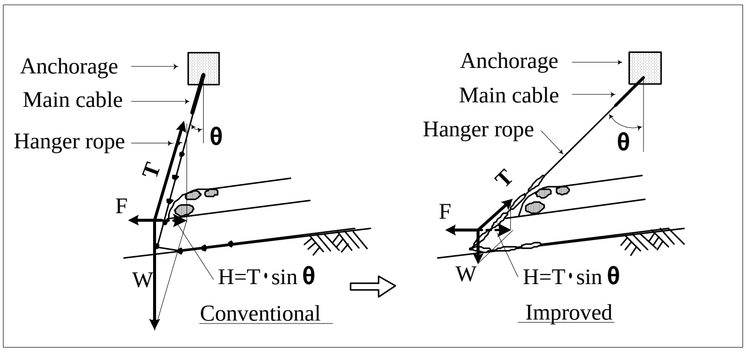

Fig. 2 ：Side view of wire net dams

1.1 Study on measures for the concentration of load on hanger ropes

The conventional net is made by fixing the intersecting points of hanger ropes and lateral ropes, which consist of steel lay wires of a wire having a diameter of ϕ1.57 mm, thereby arranging them like a lattice. When debris acts upon the hanger ropes of the net, the lateral ropes become loose. They are then unable to transmit the force to the adjoining hanger ropes, with the result that the load concentrates on one hanger rope.

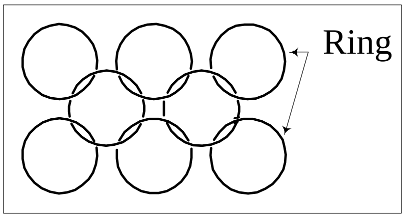

Fig. 3 ：Ring net

To avoid this phenomenon, we decided to use a ring net. A ring net is made by continuously weaving multiple rings in which several tiers of steel wires of ϕ4.5 mm are coiled in a circular shape. The method of weaving them now employed is to pass a ring through other rings as shown in **Fig. 3**.
For instance, a load that acts upon the ring in part-a of **Fig. 1** is transmitted toward the main cable, while being propagated diagonally through the rings, so the force does not concentrate on a single hanger rope.

1.2 Study on measures for the movement of hanger ropes downstream

The conventional net was hung in the vertical direction from the anchorage as shown in **Fig. 2**, and then was folded toward the upstream direction to be laid down on the riverbed. It was planned that when a debris flow acts upon the net, the net moves downstream, and the horizontal force H ($=T{\cdot}sin\theta$) that resists the debris flow load F can be obtained from the tensile force of the hanger rope T. However, the net did not move due to the weight of the debris flow, with the result that a very great tensile force acted upon the hanger rope. That is, because θ was small, the tensile force of the hanger rope required for obtaining the necessary horizontal component H ($T = H/sin\theta$) became very great.
In the improved wire net dam, in order that the hanger rope can retain an angle of $\theta = 45^{\circ}$ toward the downstream side when capturing a debris flow (see Fig. 2), we decided to retain the hanger ropes by moving them toward the downstream side when erecting the dam.

1.3 Measures for wear to wires

The wires at the ring net are steel wires of ϕ4.5 mm, which are larger than conventional steel lay wires. Also, a protective pipe has been fitted to the hanger rope that connects the main cable to the ring net, to prevent wear of the hanger rope.

1.4 External force

At the time, there were no definite criteria for debris flow load. For this reason, as the conventional wire net dam was supposed to be used for dissipating the energy of debris, only part of the debris flow load was taken into account. For the improved wire net dam, we decided to make calculations that take into account debris flow load and soil pressure together.

1.5 Measures for side leak of a subsequent flow toward the streambank

It was foreseen that a subsequent flow would not go over the captured sediment, and instead would flow out through both ends of the net. So, we provided both sides, right and left, with side nets, as shown in **Fig. 1**, thereby making the entire net take the form of a bag created by these nets together with the nets at top and bottom.

2. Examples of capturing debris flows

A stony debris flow acted upon the Tateyama-Dashiwara valley wire net dam, which had been constructed on a trial basis, and the dam captured the debris flow without any great damage. This is outlined below.

2.1 Situation of occurrence

At around 17:00 on August 26, 2003, a debris flow occurred in the Dashiwara valley and acted upon the wire net dam. The hourly precipitation around the site was about 38 - 42 mm/hr.

2.2 Planned data for Dashiwara valley wire net dam

Table 1 shows the planned data for a debris flow, and **Fig. 4** is a drawing of the general wire net dam. The diameter of the ring is set at 0.8 m, which is equal to the maximum grain size.

Table 1: Planned data for a debris flow

Catchment area	0.85 km^2	Maximum grain size	0.8 m
Rainfall intensity	137 mm/h	Debris flow peak discharge	58.4 m^3/sec
Average riverbed gradient	9.5°	Debris flow wave height	1.1 m
Debris flow width	13 m	Debris flow fluid force	33.3 kN/m

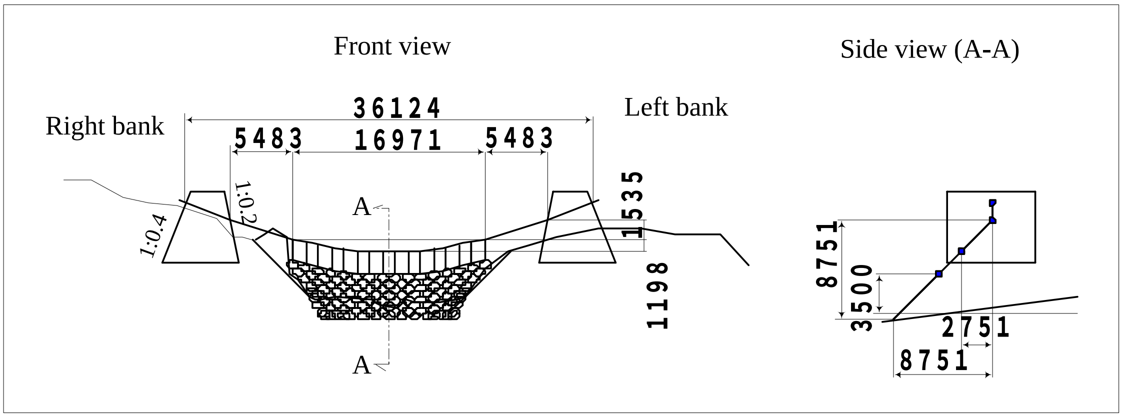

Fig. 4 ：Drawing of a general wire net dam

2.3 Situation of capturing debris flow

Photo 1 shows the situation of capturing the debris flow as taken from the downstream side, and **Photo 2** shows the same from the right bank. **Photo 3** shows a longitudinal section of sediment deposited.

By means of these photos, the debris flow-capturing effect of the improved wire net dam and the effect of structural improvements are studied below.

Photo 1 ：Situation of capturing debris flow (Front view)

Photo 2 ：Situation of capturing debris flow (Side view)

Photo 3 ：Longitudinal situation of capturing the debris

2.4 Debris flow capturing effect

1) It can be seen from **Photo 1** that the wire net dam is filled up with sediment. And, when also considering that little sediment was observed deposited downstream, it can be said that

this dam has had the effect of capturing a debris flow.

2) Based on the results of observations, it has been verified that there had been no deposition of sediment before the dam was subjected to the action of the debris flow. It can be considered from this that the dam let harmless sediment flow under normal conditions, thereby securing vacant capacity for capturing the debris flow.

3) It can be seen from **Photo 3** that debris is deposited in the vicinity of the nets, and sediment mixed with debris is deposited at its upstream side. Based on this, it is conjectured that the recent debris flow was a typical stony debris flow.

2.5 Effect of structural improvement

1) It can be seen from **Photo 1** that most of the rings have been deformed almost uniformly. It can be considered from this that the debris flow load has dispersed among all of the rings; thus, it can be said that the improvement produced the expected effect.

2) At first the moving angle of the net θ as shown in **Fig. 2** had been planned to be 45°, but the results of the survey showed that the angle should be 50 - 60°. Although there was some deviation from the initially planned value, the state of the nets moving toward the downstream direction could be secured, so it can be considered that the method of retaining the nets by moving them toward the downstream side beforehand at the time of erection was effective.

3) The results of observations showed that 2 wires of the ring nets had broken. However, the breakage caused no outflow of captured sediment. Because hardly any decrease in the cross-section was seen to be caused by wear to the ring nets, it can be considered that this breakage had been caused by some force. The cause of this breakage is a problem that should be clarified.

4) As can also be seen in **Photos 1** and **2**, almost all of the sediment was captured, therefore, it can be considered that the estimated debris flow load and soil pressure were correct.

5) The frontal part of the baglike net that had captured the debris flow moved toward the downstream side, while narrowing toward the center. As a result, the side nets on both banks, right and left, as well as the sediment outside of the nets, were separated, leaving some space there. This space served as a water channel for subsequent flows, which caused deep scouring, and this is also a problem requiring improvement.

3. Prospects for wire net dam

1) Unlike other steel sabo structures, if allowances for corrosion and wear are considered for ring nets and hanger ropes, the cross-section of the bare wire increases, so it is difficult to consider them. Therefore, it can be thought that establishment of anti-corrosion and anti-wear methods by observing the existing ring nets and hanger ropes will lead to the dissemination of wire net dams.

2) Although construction work for the improved dam was done for the first time, the period of work on the riverbed was short, at about 20 days. In the future, by making careful

arrangements for erection and by working out a better construction method, it is expected that the period of work on the riverbed will be shortened by 5 days.

3) It has been found that a considerable amount of sediment can be removed with the nets remaining intact. However, since the arm of a piece of backhoe struck the net, a group of debris at the front of the net could not be removed. The method of removing a group of debris needs to be established.

4) Because the ring diameter can be adjusted according to the maximum grain size, there is a possibility that the dam can also be applied to a debris flow of small debris.

CONCLUSION

At present we think the range of use of the wire net dam should be considered in cases such as one with: [1] a mountain stream with debris of a small diameter; [2] a mountain stream for which it is undesirable to disturb the riverbed; [3] a mountain stream for which it is desirable to shorten the period of work at the riverbed as much as possible; [4] a mountain stream for which only the wire net dam can be applied; and, [5] construction work on a trial basis. Because the wire net dam has a structure in which force acting upon the dam is supported only by the anchorages, if there is a large-scale debris flow, or if the river is wide, there is also a possibility that the anchorages will become too large, so a further study on anchorages is required.