Debris Capture Example by Flexible Barrier and Its Performance Verification

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INTRODUCTION

Flexibly structured slope failure control sediment capture works (hereinafter "impact barrier") is a type of works designed to control steep slope failure composed mainly of posts, wire ropes, nets, energy absorbers (hereinafter "brake ring") and underground reaction bodies (**Fig. 1**). This structure was so far constructed at 118 locations in Japan, and three of them were actually used to successfully capture sediment failures.

Forces in wire ropes and axial force to the post are calculated by using the static equilibrium of force based on the acting force in the net when the fence undergoes maximum deformation (**Fig. 2**). Size of cross section surfaces for each member are designed by using the allowable stress intensity method based on these forces (hereinafter the "existing design method"). The barrier is verified in a full-size experiment by validating the viability of its constituent factors including the safety factor of each member and the force equilibrium.

This paper reports the verification result of the validity of the design with (1) a design model and (2) a selection of members used as focal points while using actual sediment capture data.

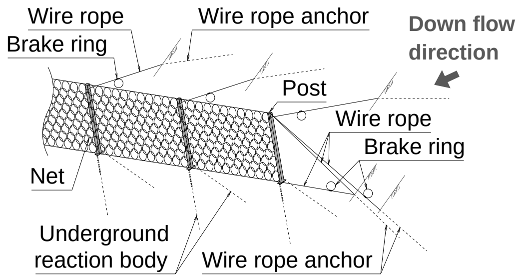

Fig. 1 Schematic diagram of structure

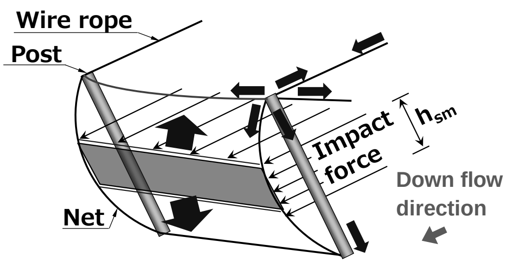

Fig. 2 Design model (under impact force)

Table 1 Design and slope failure site conditions

Item	Sign	Design conditions	Actual phenomenon
Slope height	H	92.69 m	106.9 m
Maximum failure depth	D	2.0 m	1.5 m
Height of sediment movement	h_{sm}	1.0 m	0.75 m
Slope gradient	θ	35°	37°
Effective fence height (deposit height)	h	4.5 m	(4.5 m)

OUTLINE OF SEDIMENT CAPTURE DATA

The impact barrier installed for road damage restoration work conducted in Miyazaki prefecture in FY2010 is chosen as the works subject to validation herein reported. This impact barrier has a 20 m long and 5 m high fence. When the upper part of the slope, at the foot of which this barrier was constructed, failed as a result of heavy rainfall in July 2012, the barrier captured sediment that collapsed from the slope.

Fig. 3 shows the barrier when completed, while **Figs. 4** and **5** show the barrier when it captured the sediment. The design conditions and the field slope failure conditions confirmed by the follow-up survey are shown in **Table 1**. **Fig. 6** shows schematic sectional diagrams of the fence in its design condition and in the condition when it captured the sediment. The maximum failure depth estimated from the ground surface line before and after the slope failure is about 1.5 m (**Fig. 7**).

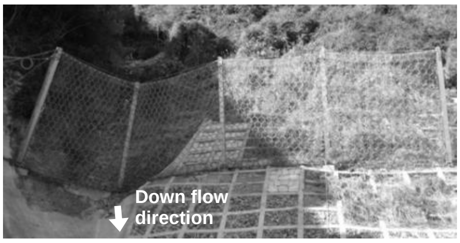

Fig. 3 Works completed

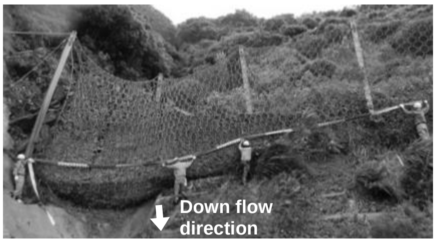

Fig. 4 Capture of sediment

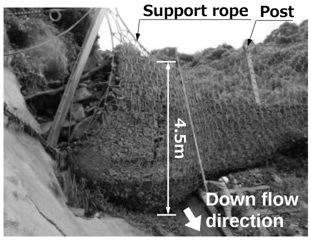

Fig. 5 Sediment deposit height

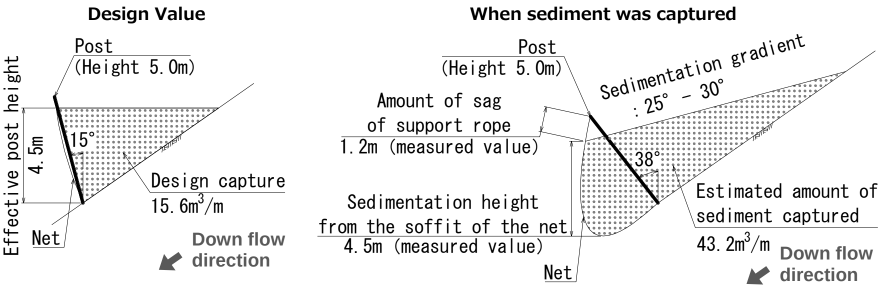

Fig. 6 Schematic sectional diagrams of the fence in the design conditions and in the sediment capture condition

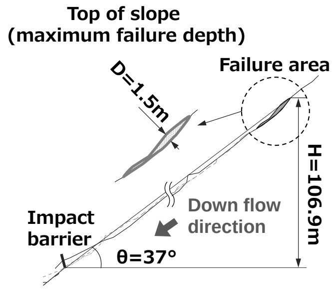

Fig. 7 Condition of collapse at the slope failure site

COMPARISON BETWEEN FOLLOW-UP SURVEY RESULTS AND CALCULATED VALUE OF THE EXISTING DESIGN METHOD

We have compared the debris captured results with the results calculated by the existing designing method in same condition from below points of view and drew some conclusions about the safety level of existing designing method.

1. Comparison of forces working on the impact barrier
2. Comparison of the amount of sediment captured
3. Comparison of force working on members
4. Member Deformation

CONCLUSIONS

The amount of sediment captured and the force working on the wire rope were verified base on the condition of the slope after failure and the condition of the captured sediment. The impact barrier chosen as the subject of verification is a structure that satisfies the three conditions required of a sediment capture works for steep slope failure control. To be specific, this structure is (1) a structure that satisfies the conditions specified by MLIT Notification No. 332, (2) a structure that resists the predetermined deposited earth pressure, and (3) a structure that can maintain the predetermined amount of sediment to be captured. In addition, the existing design method is confirmed to be the safe-side design method that has a margin of an approximate factor equal to or more in terms of the design model and selection of members.

We have identified some tasks to solve in the future. To be specific, we will need to conduct a dynamic material tensile test for the brake ring and understand the relationship with the load and travel in order to ensure a precise evaluation of working force under the impact of a sediment failure. We will also need to conduct more follow-up surveys and enhance the reliability for validity of the design method by the verification method used herein.

Keywords: debris capture, performance verification, existing designing method