Study on Flow Velocity of Bouldery Debris Flow on Impact Load Acting on Flexible Barriers

Yuta Miyahara[1], Toshiyuki Horiguchi[1]
[1] National Defense Academy

Every year in Japan, debris flow disasters cause severe damage and pose a significant threat to human life. In particular, the frequency of such disasters caused in small-scale streams has increased. Consequently, the need for effective mitigation measures in such environments has become urgent. However, implementing these measures is challenging because small-scale streams are often adjacent to residential areas, leaving limited space for construction.

Flexible barriers have been widely adopted as protective structures due to their relatively light weight, ease of installation, and suitability for narrow construction sites. Despite their widespread use, their structural performance under debris flow impact remains vague. Therefore, this study focuses on debris flow patterns and examines how these patterns influence the impact on flexible barriers.

A series of flume experiments was conducted to investigate different patterns of debris flow impacting a flexible barrier model. The debris flow models have different flow velocities and depths. Two types of flexible barrier models were tested "one made with steel wires and the other with nylon nets" to evaluate the effect of barrier material stiffness. Additionally, a rigid barrier model was inclined as a reference to quantify the relative buffering capacity of flexible systems.

The experimental results indicate that the maximum tensile force in the lower rope of a flexible barrier occurs as the debris flow pressure reaches the middle height of the barrier, while the maximum tensile force in the upper rope occurs when the flow reaches the top of the barrier. The tensile force in the rope of steel wire model was larger than that of the nylon net model. In contrast, there was little difference in impact load acting on two types of flexible barriers.

Furthermore, the tests demonstrate that flexible barriers can reduce peak impact loads by up to approximately 50 % compared to rigid barriers, thereby enhancing energy dissipation under debris flow events. Nonetheless, in some scenarios, the peak impact loads on flexible and rigid barriers were nearly identical.

These findings reveal that debris flow velocity significantly affects the impact buffering capability of flexible barriers. As flow velocity increases, the effectiveness of flexible barriers to reduce impact loads diminishes, making their performance converge with that of rigid barriers. These insights contribute to a more comprehensive understanding of debris flow protective structure and provide guidance for the design, placement, and implementation of flexible barriers in small-scale streams.