39th IABSE Symposium – *Engineering the Future*
September 21-23 2017, Vancouver, Canada

Debris barrier design using energy-balance techniques

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Abstract

The design of structures that are intended to protect inhabited areas and infrastructure from debris mass movement events poses particular challenges. The impact of a debris flow places an energy demand on the structure and traditional quasi-static design approaches are limited by the arbitrary selection of dynamic impact factors. For debris barrier design, an energy-balance approach, that equates the internal work of the structural elements to the kinetic energy of impact, is appropriate. Two recent flexible grillage debris barrier projects near the Resort Municipality of Whistler illustrate the application of this technique.

Keywords: debris barrier structural design, debris flows, debris floods, impact loads, energy balance, strain energy analysis, flexible grillage debris barriers

1 Introduction

Debris barriers on mountain streams must allow regular clear-water flows to pass unmolested while retaining debris from mass transport events. These structures are subjected to significant impact loads from debris fronts, as well as horizontal pressures from post-event impounded debris. This paper presents the analytical approach used in designing for debris impact and key energy-absorbing design features of barrier structures. Two recent debris barriers designed to protect the village of Whistler in British Columbia provide examples of the approach. The barriers feature a central passage screened by articulated steel grillages designed by balancing the kinetic energy of debris impact with the available internal work of the structural system.

2 General characteristics of debris events

Natural soil mass movement occurs through many processes, ranging from sediments suspended in flowing streams to rock falls. Some are continuous processes, others are episodic. Hydraulic design methods are appropriate for events that are primarily comprised of flowing water, but for events comprising a significant amount of debris such methods are less appropriate due to the transient nature of the loading. Figure 1 illustrate the mechanisms by which debris is transported. The structures discussed here mitigate events ranging from debris floods to debris flows.

Hungr[1] provides the following definitions for these debris transport events: a *debris flood* is a very rapid, surging flow of water, heavily charged with debris, in a steep channel while a *debris flow* is a very rapid to extremely rapid flow of saturated non-plastic debris in a steep channel.

3 Nature of loading due to debris events

In general terms, a mass transport event results in the impact of the debris barrier structure by one or more debris surge fronts, as illustrated in Figure 2. Local point impacts, due to saultating boulders, entrained tree trunks, etc., will also load the structure. Once the initial debris surge has

https://doi.org/10.2749/vancouver.2017.2872
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