SEDIMENT CONTROL FUNCTION OF CLOSE TYPE CHECK DAM

RABINDRA OSTI[1], SHINJI EGASHIRA[2] and TAKAHIRO ITOH[3]

[1]Doctoral student of Ritsumeikan University, Noji Higashi 1-1-1,
Kusatsu, Shiga 525-8577, Japan
(Tel: +81-77-561-2732, Fax: +81-77-561-2667, e-mail: gr019026@se.ritsumei.ac.jp)
[2]Professor, Dept. of Civil and Environmental Systems Engineering, Ritsumeikan
University, Noji Higashi 1-1-1, Kusatsu, Shiga 525-8577, Japan
(Tel: +81-77-561-2732, Fax: +81-77-561-2667, e-mail: egashira@se.ritsumei.ac.jp)
[3]Assistant Professor, Dept. of Civil and Environmental Systems Engineering, Ritsumeikan
University, Noji Higashi 1-1-1, Kusatsu, Shiga 525-8577, Japan
(Tel: +81-77-561-5035, Fax: +81-77-561-2667, e-mail: itoht@se.ritsumei.ac.jp)

In mountain torrents, check dams are useful for controlling debris flows quantitatively and qualitatively. In fact, various kinds of the dams such as close-type, slit-type etc. have been constructed and expected to control sediment volume, sediment size and hydrograph of debris flow. Such control functions of the check dams are reported in many experimental and computational studies. These studies have contributed to understandings of control functions of check dams. However, further studies are needed to develop a general criterion for debris flow control function corresponding to each type of check dams. Present study discusses a criterion of control function for close type check dam with attention focused on potential storage volume of the check dam, supplying and out-flowing sediment volumes, supposing that the debris flow can be controlled due to the change of stored sediment volume although the storage area is initially filled up of sediment to the level of the dam crest.

The sediment control or the debris flow control by a close type check dam whose storage area is filled up of sediment is explained based on Fig. 1 (a). If debris flow takes place and continues to flow, the dam will lose its control function gradually. However, it is expected that the dam can control debris flow and change its characteristics when bed slope of storage area is less than the corresponding equilibrium bed slope. In order to evaluate sediment control more generally as possible as we can, we will introduce a concept of potential storage volume, V_p, which is defined as:

$$V_p = \frac{(H_d \cos\theta)^2 B}{2} \cdot \left\{ \frac{1}{\tan(\theta - \theta_e)} - \frac{1}{\tan(\theta - \theta_0)} \right\} \quad (1)$$

in which H_d is the height of dam, B is the flow width, θ is the slope of original torrent bed, θ_0 is the initial bed slope of storage area before occurring debris flow and θ_e is the equilibrium bed slope corresponding to the sediment concentration of debris flow. It is considered that the original bed slope, θ, is always larger than the corresponding equilibrium bed slope, θ_e.

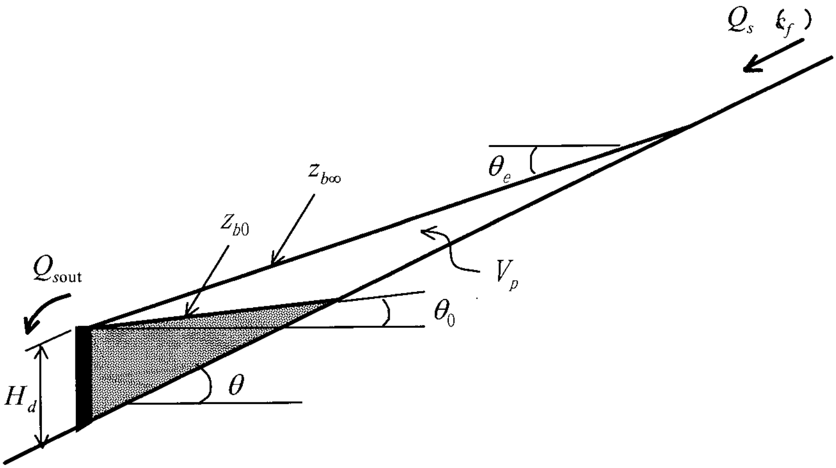
It is convenient to obtain a non-dimensional form for potential storage volume in discussing problems associated with sediment control. Equation (1) yields:

$$V_{p*} = \frac{V_p}{\dfrac{H_d^2 B}{2} \dfrac{\cos^2 \theta}{\tan(\theta - \theta_e)}} = 1 - \frac{\tan(\theta - \theta_e)}{\tan(\theta - \theta_0)} \tag{2}$$

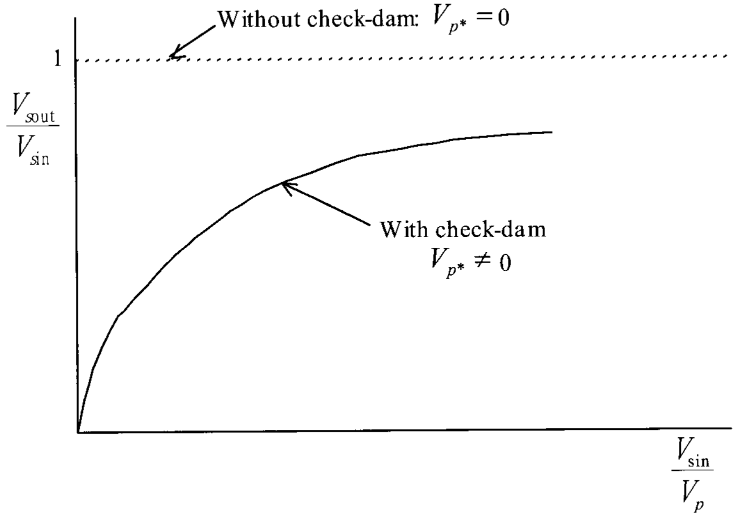
The value of V_{p*} ranges from zero to unity ($0 \leq V_{p*} \leq 1$). In addition, it is suggested that a check dam will be more effective if V_{p*} increases toward unity and, in contrast, will lose its control function if V_{p*} tends to be zero. The condition that there are no dam can be expressed as $H_d = 0$ and $\theta = \theta_0$.

Fig. 1 (b), a relation between relative outflow sediment volume, V_{sout}/V_{sin}, and normalized inflow sediment volume, V_{sin}/V_p, is shown in schematically. Herein, V_{sin} is the total amount of sediment volume transported from upstream and V_{sout} is the total outflow sediment volume from the dam. It is considered that debris flow can be controlled well if the normalized inflow sediment volume is small. In contrast, the dam will lose its control function if the normalized inflow sediment volume increases infinitely. It should be noted that debris flow size will develop if initial bed slope of storage area, θ_0, is steeper than θ_e. Discussions will be made on sediment control in the conditions with $\theta_0 < \theta_e$.

Moreover, in present studies, flume tests and numerical computations are conducted to investigate debris flow characteristics passing through the check dam as well as to develop a general criterion for the control function of the check dam. The relative outflow sediment volume, which is normalized by inflow sediment volume, can be evaluated well using two non-dimensional parameter; relative inflow sediment volume and non-dimensional potential storage volume. It is also expected that the results will help us to optimize the size and the location of check dam in the steep mountain torrents.



(a) Schematics of close type check dam.



(b) Relation between inflow and outflow sediment volume.

Fig. 1 Sediment control function using potential storage volume of check dam.