DESTRUCTION MECHANISM OF NATURAL DAM MADE OF UNIFORM AND NON-UNIFORM BED MATERIALS IN A STEEP SLOPE CHANNEL

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Introduction

Among many causes, the root cause of formation of natural dam in a narrow gorge of steep slope channel is collapse of banks. The dam formed in such a way impounds the huge amount of water for the time being. Forces of flowing water in and over the dam and pressure of detained mass of water cause sudden movement of dam forming materials along with the water and debris flow is likely to occur in downstream of channel. The destruction mechanism of a natural dam varies with the characteristics of dam forming materials and channel as well as discharge.

The main objective of this study is to observe the process of destruction mechanism of natural dam made of uniform and non-uniform bed materials of various sizes.

Experimental Set-up and procedure

Experiments were conducted in an indoor laboratory flume of 15cm in width, 30cm in height and 10m in length. The flume was equipped with the mechanism of adjustable bed slope and transparent sidewall at both sides. All experiments of the present study were done at the slope of 1/5.57. For uniform mixture of bed materials, a dam (15cm wide, 10cm deep and 1m long) was made of sand or gravel of almost uniform grain size of 1, 4, 7, and 15mm. In the case of non-uniform mixture of bed material, all previously mentioned sizes were mixed in equal proportion by volume and dam was made out of that mixture.

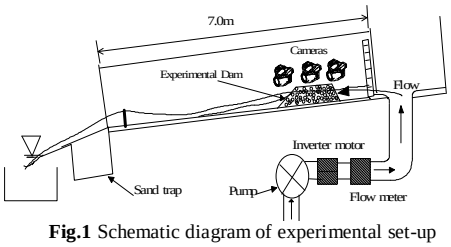

Fig.1 Schematic diagram of experimental set-up

For each case, experiment was carried out changing the discharge of water. A constant discharge was supplied until the destruction of dam completed out of its original position and water discharge was reckoned manually using a measuring bucket and a stopwatch in each case. Three video cameras were set at different positions to take continuous and simultaneous measurements. Schematic figure of experimental set-up is shown in Fig.1.

Results and discussion

Types of collapse

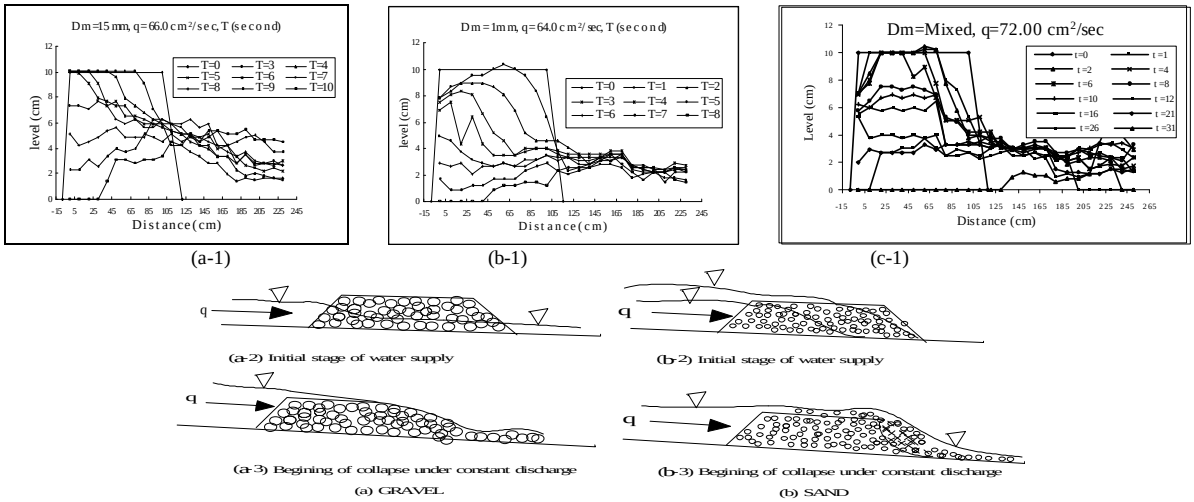

Fig.2 Actual and schematic diagrams of collapse phenomena with the size of dam forming materials

Observation during the experiments revealed that the grain size of dam forming material is one of the crucial parameters governing the destruction mechanism of the natural dam.

Schematic diagrams in Fig.2 show how the collapse of dam proceeds with the grain size and composition of bed

Key words: debris flow, natural dam, grain size
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forming materials. Graph (a-1) represents the actual destruction phenomenum of dam made of uniform large sized particles. Similarly, plots (b-1) and (c-1) depict actual process of destruction phenomena of experiments of dam made of uniform small particles and mixed or well graded composition of bed materials. In the case of uniform smaller particles and mixed one, flow proceeds as shown in diagram (b-2) and eventually collapse results as diagram (b-3). A portion of flow enters into the dam body itself and the remaining part accumulates and sets the upstream rising. Surface flow over the dam results as water level surpasses the height of dam. Seepage and over toped flow advances in the downstream direction. As overtopping of flow begins, it erodes particles from the dam surface and a part of downstream face collapses initiating the destruction of dam and continues as shown in (b-1) and (c-1). However, in the case of larger particles, a considerable part of flow percolates through dam body itself as shown in (a-2). The rate of percolation is faster and greater than the setting of water level upstream of the dam. The initiation of destruction starts at the toe of dam where the seepage water emerges on the surface as shown in (a-3).

Example of experimental results are depicted in the graphical plots (a-1), (b-1) and (c-1) of Fig.2. Initial destruction was begun on downstream face of the dam and proceeded rapidly and progressively towards the upstream direction in the case of the dam made of larger-sized particles. Progressive failure seems to proceed in upstream direction. The destruction was rather faster in case of small-sized particles.

Temporal variation of eroded volume

The eroded volume, V_e is defined by the volume eroded (accumulated) and transported from the original dam volume V_0 at a time concerned. Fig.3 comply with the experimental observation made during intiation process of debris flow with different grain sizes under almost same discharge. The eroded volume, at the onset of the destruction, is larger in case of smaller particles and keeps advancing almost steadily. However, in the event of large-sized particles, the rate of eroded volume is smaller at the beginning of destruction and increases as the time goes by. It implies that in case of small-sized particles, surface erosion and collapse of frontal part because of large differential pressure (large pressure difference saturated and unsaturated mass) of dam cause eroding more volume than that of large-sized particles.

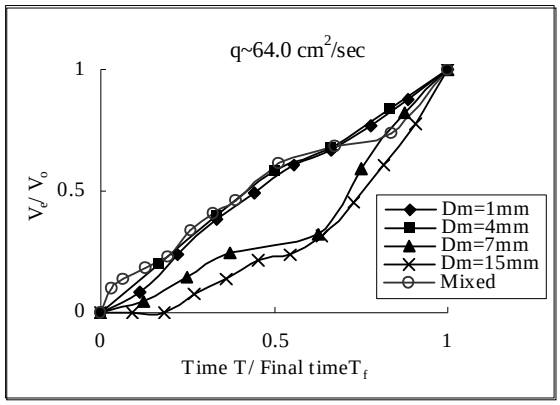

Fig.3 Relationship between V_e/V_o and T/T_f in terms of variation in size and composition of dam forming materials

Temporal scouring

Fig.4 shows the temporal change in bed level at some locations with the supply of approximately same discharge for uniform and non-uniform bed materials. From the figure, one can notice that to scour a given depth mixed material takes longer time than uniform ones. Moreover, among the uniform materials, larger sizes take longer time except the smallest size i.e., 1mm. It might be due to the presence of cohesion in the case of smallest one and physical bonding with cohesion in the case of mixed particles.

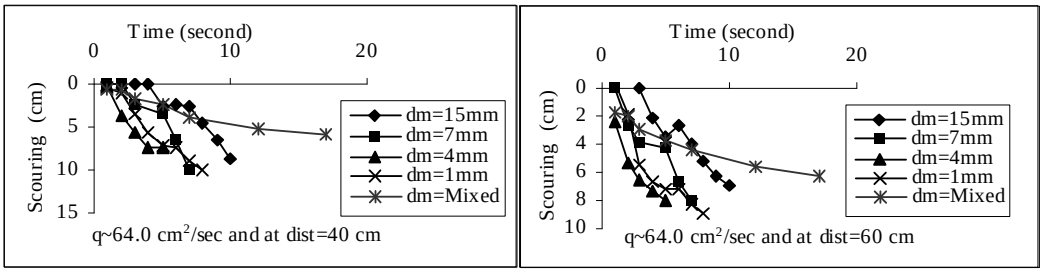

Fig.4 Souring at particular locations of the dam with time

Conclusion

As for the uniform larger particles, part of the discharge seepage through the dam body creating a slippage and collapse proceeded in upstream direction. Eroded volume of the dam forming material is smaller at the beginning of collapse and increases as the time goes by. On the other hand, mechanism of destruction seems similar in both cases of smaller sized uniform materials and mixed one and only the difference is in timing. Bed material of dam eroded almost steadily. The destruction process of natural dam is a complex process and seems governed by many factors. Among them supplied discharge, depth of flow, characteristic of dam forming materials i.e. permeability, size, cohesion, angle of repose of materials and so on are seem the important factors to be considered in future research to analyze the phenomena.

Reference

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