

Properties of the Dammed Moraine of the Glacial Lake and Some Analytic Examinations of Collapse of It in Bhutan Himalaya

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1.Introduction

In late years, Glacial Lake Outburst Flood (GLOF), it caused by melting of the glacier with the climatic variation and dammed with the moraine, is one of social problem in the Himalayas region. In this report, results examined about the properties of the materials making the moraine dam and sampling in Bhutani Himalayan glacial lakes are reported. Subsequently, with the existing software, the results that examined for the overflow collapse were examined with its parameters as above results analytically.

2. Sampling places and the properties of it

Komori, Takenaka and Phuntso went to the investigation along Mande chuu from September 9 to October 15, 2009. The samples were gathered in its process. Because the overflow collapse was assumed in this report, some tests for the properties of the materials were made. And the specific gravity of the soil particles, bulk density and the particle size distribution were made clear by it. Examined results are shown in Table-1 and Fig.-1. The bulk density was a different value in the sample of Lake A and Lake D. As for the degree of porosity calculated by these values, Lake A was 34.6% and Lake D was 49.4%. Because these samples are sandy soil, the condition of Lake D will be in loosely.

3.The examination of the collapse that used overflow analysis software

Umemura (2009) showed that in the case of an overflow collapse, the slops gradient of the moraine dam is not the main factor of it, and on the other hand, the amount of the overflow and the duration time is one of the main factors. Therefore, in this report, we examined in this. It was carried out with relating as follows to be concrete; 1) When the water which flows into the glacial

Table-1 Physical properties of dammed material (by JIS A 1202)

	Lake A (Bhutan)	Lake D (Bhutan)
Specific gravity of soil particles	2.635g/cm ³	2.641g/cm ³
Bulk density	1.723 g/cm ³	1.336 g/cm ³

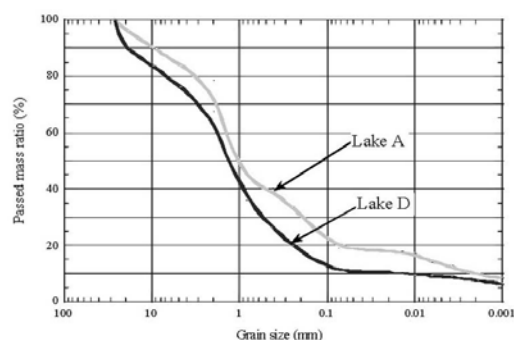


Fig. -1 Grain size distribution curve (by sieve and hydrometer method)

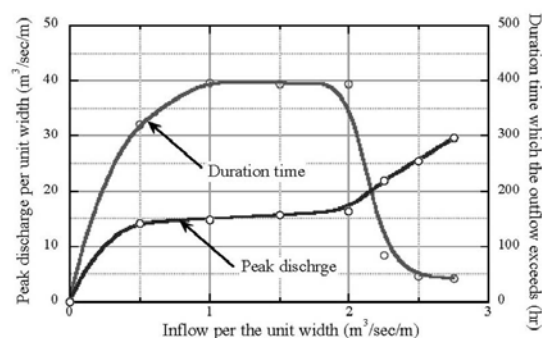


Fig. -2 Relationship of the peak discharge and the duration time with the change of the inflow (by BREACH model analysis)

lake from upstream increases and lake water face rises and goes overflow, 2) Because tsunami occurred by rock fall and such kind of rushing to glacial lake, and the upper part of dam was destroyed, and its top level lowered than the surface of lake water, the overflow in the process to the lake water to the position of the top level of dam. And an effect of the inflow was examined under the condition that upstream gave quantity of water constantly. For analysis, the analysis software by the BREACH model (Boss International Company) was used. The geometry data were fixed and the material parameters which were got from the test were used. However, the values that Umemura found in Imja Tsho glacial lake in Nepal were used for deficient parameters. And the quantity of inflow was changed step by step. An example of the results is shown in Fig.-2. When the inflow was given for a dam, a top of it was eroded by the initial stage and produces peak in the outflow. However, the outflows did not need to increase rapidly, and erosion continued to long time and showed tendency to gradually stabilize. On the other hand, when inflows increased, it presented rapid peak in the initial stage, and quantity of outflow increased. And an outflow did not continue and it tended to be stabilized in hour.

The tendency of the latter was a scenario of the collapse to debris avalanchization. It was thought that the collapse in such a tendency was equivalent to high-risk GLOF.

4. Summary

1) The properties of the material which constituted the dammed moraine of the glacial lake which developed in the Bhutani Himalayas were shown.

2) As a result of analysis, an inflow from upstream to give a dam had an influence on the presence of the debris avalanchization at the time of the collapse in the case of the overflow.

From this, data to affect the inflow outflow of the glacial lake, the data about the water budget was useful was suggested by the hazard of the glacial lake outburst.

Keywords: Bhutan, Glacial Lake Outburst Flood, Dammed moraine, Physical property, Analysis of Collapse of Dam caused by overflow