MATHEMATICAL MODELLING OF FLOOD AND DEBRIS FLOWS CAUSED BY OUTBURSTS FROM HIGH MOUNTAIN LAKES

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INTRODUCTION

This paper discusses three models related to catastrophic hydrological occurrences in the mountains. The first model calculates and predicts a hydrograph of ice-dammed lake outbursts; the second model calculates the occurrence probability distribution of the volumes and maximum discharge of water from moraine lakes; and the third one computes the volume and discharge of flood water from the hydrograph as well as the volume and maximum discharge of debris flow. The three models are developed for high elevation mountains where occurrences of glacial outbursts are quite common.

Glacial outburst flood are quite rare on a particular site, but, in general, they are quite common in mountains of high elevations. This paper presents the principles of modelling of two dangerous hydrologic occurrences: outbursts from the ice-dammed lakes, and of moraine lakes.

OUTBURSTS FROM ICE-DAMMED LAKES

Satellite photographs and glacial monitoring should provide sufficient information about the appearance and conditions of ice-dammed lakes. However, for forecasting purposes, it is beneficial to also have a mathematical model of the hydrograph of the flood expected from such an outburst flood.

The process of discharge from the ice-dammed lake, starting from the beginning of the leakage in the ice-dam, is considered. The leakage process is defined by two main sources: the increasing cross-sectional area of the tunnel and the decline in the hydrostatic pressure due to a decreasing water volume in the lake. The assumption is that the potential energy of the water in the lake will be completely spent on the tunnel melt.

The modelling equation for the relationship between rate of expansion of the tunnel and decline of water volume in the lake is discussed.

The model computing outburst hydrographs with their characteristically strong negative asymmetry was validated for the following lakes: Lake George in the Chugach Mountains, Lake Alaska (1951), Lake Talsequa on the Coastal Ridge on the border of British Columbia and Alaska (1958), glacier lakes Medvezhii, in the western Pamir Mountains (1973), and Grenalown (1935, 1939) and Grimsvetn (1922, 1934, 1945) both in Iceland. Sufficient correspondence of the model was obtained with somewhat vague data for the lake Vatnsdalur (1898) in Iceland and the Pleistocene Missoula Lake in the Columbia River Basin.

In cases when the tunnel diameter is approaching dimensions corresponding to the size of the ice-dam, the model should be applied with great care.

MORAINE LAKE OUTBURST

Moraine lakes are very common in conditions of high elevation mountains. They appear, evolve, and disappear. Sometimes they burst out catastrophically. Forecasting such outbursts is best accomplished by using graphs showing temporal increases in water volumes in the lakes. If the graph curve has a parabolic shape, and the annual increment in water volume increases consistently, the outburst probability is very high.

For purposes of ecological planning in mountainous terrains with moraine lakes, the probability distribution curves of lake volumes and maximum discharge rates are required. Methods of calculation of such curves are not available. Nevertheless, there are some possibilities to obtain such distribution curves by mathematical modelling under some reasonable assumptions. The technique for such modelling, mainly stochastic but with some elements of deterministic approach, is discussed.

The methodology of the modelling can be applied to any high elevation mountain terrain, e.g. the Himalayas, Hindu Kush, Karakoram, Tibet, Andes, etc.

DEBRIS FLOWS

In many cases, the proposed algorithms can be combined with the model of the transport-dislocation debris flows process. As a result, characteristics of a given probability for debris flows can be obtained. This process can occur only on the slopes that exceed the critical value.

Some of the problems stated in this paper are considered in more detail by Vinogradov (1977 and 1980).

REFERENCES

Vinogradov, Yu.B., 1977. *Glacialnye proryvnye pavodki i selevie potoki* (p156). Gidrometeoizdat, Leningrad (In Russian).

Vinogradov, Yu.B., 1980. *Etudy o selevyh potokah* (pp144). Gidrometeoizdat, Leningrad (In Russian).