EXPERIMENTAL STUDY OF CHANGE OF THE WATER LEVEL IN A NATURAL LAKE BY THE INRUSH OF A DEBRIS FLOW

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OBJECTIVE

When multiple natural dams have been formed on a single torrent as occurred in the Imo River Basin during the Niigata-ken Chuetsu Earthquake of 2004, the first response is to predict the danger that each natural dam will collapse. When, as a result, it is predicted that an upstream natural dam will collapse before a natural dam located further downstream in the same river, it is necessary to judge the immanence of the collapse of the downstream natural dam considering the collapse of the upstream dam.

When an upstream dam has collapsed, the quantity of water and sediment flowing into the natural lake of the downstream natural dam rises rapidly, increasing the quantity of water and forming waves. The immanence of its collapse is judged by estimating the time until the stored water begins to flow over the top of the natural dam and the time until the seepage line inside the natural dam reaches the downstream edge. Generally the rise of the water level and transmission of waves occur faster than the advance of the seepage line, so the object of the judgment should be collapse caused by overflow. In order to judge collapse caused by overflow, it is necessary to consider the water level that rises as the quantity of stored water increases and the run-up on the natural dam of the waves formed by the inrush of a debris flow from upstream into the natural lake. Regarding the former, the time until collapse can be estimated by adding that on the upstream side to the quantity of water held back by the downstream natural dam. But to obtain the latter, the height of the run-up of the waves must be estimated.

The run-up height of the waves is impacted greatly by the factors: wave height, wave length and topographical conditions (gradient). It is reported that the higher the speed of the inrush of a soil mass or sediment into the water-covered area, the higher the waves created by this inrush. It has been reported that the higher the value obtained by dividing the inrush speed by the speed of the long wave (dimensionless speed), the higher the run-up. In an actual torrent, river width varies, and the water level on the water-covered area also fluctuates from empty to full state, requiring that the run-up height be obtained by a method that considers these fluctuations. But no past research has systematically varied the water level and river width.

This research was undertaken to qualitatively clarify the relationship of the run-up height of the waves formed by the inrush of water and sediment into the natural lake with the river width and water level based on flume experiments and numerical calculations of the two dimensional shallow water equations by the finite volume method. This research was a study of

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the run-up height - water level relationship based on channel experiments and the run-up height - river width relationship based on numerical calculations.

RESULTS

Figure 1 plots the Froude number of the flow entering the natural lake on the Y axis and the run-up height ratio on the Y axis, based on the results of the channel experiments. The higher the Froude number, the higher the run-up height ratio. The greater the initial depth in the natural lake, the smaller the run-up height ratio is.

Figure 2 shows the relationship between the run-up height ratio and the flume width ratio based on the results of the numerical calculation. Figure 2 shows that the narrower the water-covered area in comparison with the river, the higher the run-up height ratio.

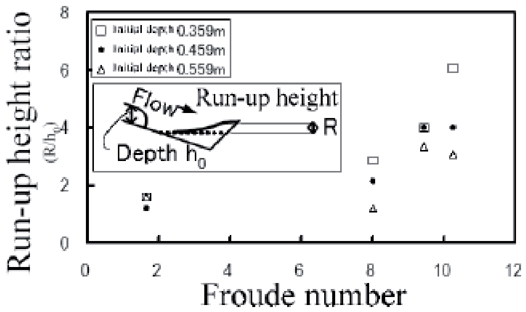

Fig.1 R/h$_0$ and Froude number (Exp.)

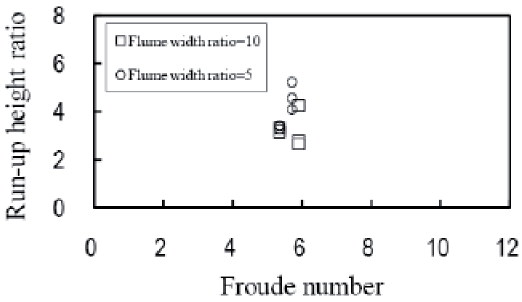

Fig.2 R/h$_0$ and Froude number (Cal.)

CONCLUSIONS

The run-up height ratio is impacted not only by the hydraulic conditions of the flow entering the natural dam, but also by topographical conditions such as the ratio of the river width and the natural lake width. Concerning this point, it can be stated that the numerical calculation model is a powerful tool for the estimation of the run-up height because it can account for topographical conditions at the site. In the future, we wish to improve the numerical calculation model so that it can more precisely reproduce the deposition process of the sediment in the natural dam.