Development of Technology for Capture of Levee Collapse from Water Level Observation

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1. Introduction

The necessity of understanding the occurrence of flooding more quickly, even under difficult circumstances in which a large number of overflows occur in a concentrated manner, has become clear from the damage caused by heavy rains in recent years. When a levee collapses, the large outflow (flooding) of river water causes a depression in the water surface in the vicinity of the levee breach, and that depression then propagates upstream and downstream in the river as a kind of wave. The following presents an outline of the development of a technology for detecting the occurrence of levee collapse from this phenomenon and, in addition, estimating the volume of the flood flow.

2. Reading the signal of levee collapse

An example of water level observation in the vicinity of a levee breach is shown in the upper part of **Fig.-1**. The video taken at the site recorded the two points in time of collapse of the backside slope of the levee and flooding caused by the levee breach. Although the levee collapse occurred at some point during this interval, no conspicuous change can be seen. Therefore, the figure was redrawn (lower part of Fig.-1) as the water level change ΔH from the immediately prior water level observation, and showed that a sudden water level drop of about 10 cm occurred. This is the signal of levee collapse, and the method of reading that signal in real time is the core of the detection technology. It was possible to extract signals (although containing noise) by quantifying whether a sudden change occurred (raw score) using an autoregression (AR) model, and then filtering for a sudden water level drop of a magnitude that could occur during a levee breach (score including propagation characteristics). When the scores of water level gauges at other locations were calculated in the same manner, signals were also extracted at almost the same time, as predicted from the propagation characteristics of the depression. We are currently attempting to eliminate noise and improve the accuracy of levee collapse detection through repeated ingenuities based on these propagation characteristics.

3. Estimation of flood flow from change of water surface during flooding

The flood flow volume changes depending on the width of the opening in a levee (width of the levee breach). Here, the key to the development is how to overcome the difficulty of determining the width of the levee breach, which expands instant by instant during a breach. Reasoning by analogy from experiences showing that the water depth in a tank can be reduced more rapidly by opening the tap wider, it should also be possible to back-calculate the width of a levee breach from the progress of water level decrease. The core element of the estimation technology based on this idea is a technique for capturing the water surface depression under increases and decreases in the water level by flooding. Here, the particle method which is used in "flood damage risk lines" was applied. A large number of real-time flood flow analyses (called "particles") which were given different levee breach widths were conducted, and the results were narrowed to particles having a breach width corresponding to the depression by assimilating the observed water levels to the results (lower part of **Fig.-2**: The C-value is a parameter equivalent to the breach width). When the flood flow volume was estimated assuming that detection is possible 20 minutes after a levee collapse occurs (i.e., after 2 water level observations) by the above-mentioned score, satisfactory results were obtained, as shown in the upper part of Fig.-2. We are currently conducting further research on use of this technique in flood prediction, for example, in forecasting the extent of the inundated area.

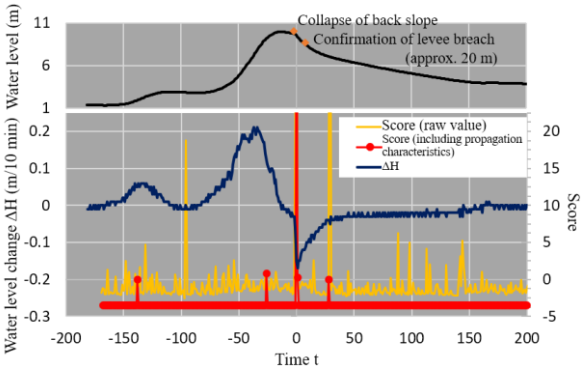

Fig.-1 Water level observation in vicinity of levee breach and score values

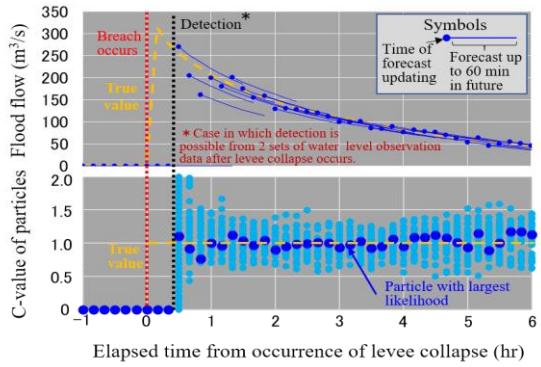

Fig.-2 Example of estimation of flood flow by particle method