Challenge for Uncertainty

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1. Introduction

When society was not mature, there were vast wild frontiers and investment in such frontiers could earn very high returns. At such times, investment in technical development was also low-risk and high-return. Cost performance was also high since it was possible to choose fields with high efficiency of development. However, as potential of development has been shrinking in accordance with the progress of natural science, it would be very difficult to achieve a high return without innovative idea. On the contrary, without combination of or approach to fields other than natural science, it is difficult to achieve a return.

Meanwhile, we are faced with new challenges. Climate change by global warming has been increasing the frequency of disasters that had occurred at low frequency, and fear for major disasters is never groundless but is becoming a reality. Moreover, depopulation due to the progress in declining birthrate and aging population has been increasing the fear for "disappearance of municipalities."

This paper discusses the limit of existing technologies and a direction to overcome such new issues.

2. Geophysical soil investigation technology

Levees have the following characteristics.

1) Cross and vertical sections consist of non-uniform construction materials due to the long history of construction.
2) The soil of the ground is non-uniform in vertical section.
3) Subject to the effect of river channel, which significantly changes according to floods, which occur at irregular frequency and magnitude and are difficult to predict the occurrence.

It is therefore difficult to grasp the condition of levees spatiotemporally and continuously, and the required safety of levees is considered to have been secured by defining / securing the shape and material based on the long-term experience and performance.

As an approach to grasp continuously the property of levees and their foundation ground, the geophysical exploration method using vibration, electrical conductivity, etc. is being studied. If the study of this method gives a solution to the issue of non-uniformity in levees and foundation ground, it is expected to open a new era for levee management.

The present level of the geophysical exploration method is at most the estimation of soil classification. At present, detailed inspection of levees is based on boring survey. If this method aims to replace the present method, it would be a long-term objective to ensure the same precision as in the present level of boring survey. It is an important approach to pursue this new method. However, it is not necessary to limit the use of geophysical exploration, which is characterized by continuous grasp of the condition of levees, to replacement of boring survey for obtaining accurate information on the location.

Meanwhile, field sides desire to raise efficiency of flood control activities due mainly to the reduced number of flood-fighting team members and require technologies that are immediately available. To respond to pressing issues even in part, an approach for how to use geophysical exploration would be possible if the ratio of correct results using geophysical exploration is 60 or 70 percent, although it would be useless if the ratio of correct results is 50 percent or less.

Given the amount of information and precision, the present level of geophysical exploration may be useless for designing levees. However, since the amount of information available in risk management is limited on the whole, even uncertain information obtained from geophysical exploration may be helpful depending on how to interpret or use the information obtained. On the contrary, such approach is expected to clarify the outlet of development by geophysical exploration method and accelerate technical development.

3. Flood forecasting technology

For the rivers designated for flood forecast, the river administrators announce flood forecast jointly with the Meteorological Agency. Flood forecast aims to support

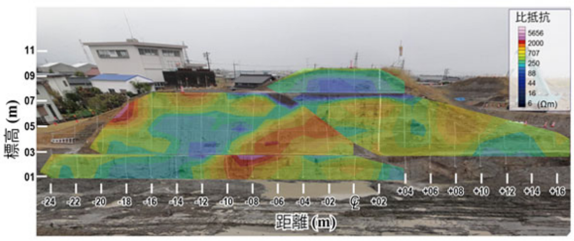

Figure 1: Comparison of levee section and geophysical exploration results [1)]

evacuation and the present level of forecast responds to floods, as assumed conventionally, where one or two hours are required for evacuation (including evacuation lead time). For this reason, the flood forecast mainly adopted at present forecasts water level about 3 hours later based on the data on past precipitations and water levels. This method has limitations on forecasting the time of flood occurrence but allows for rough judgment of rise / fall in water level based on the accumulated precipitation and for forecast of water levels with a certain level of accuracy based on correlation with upstream water level.

On the other hand, the present forecasting technology, which is based on actual precipitations and water levels, is not able to respond to cases where one or two hours are required for evacuation due to large-scale flood caused as a result of climate change etc. or where several tens of minutes are required for evacuation due to localization / centralization.

In order to ensure such lead time as responds to disasters, utilization of precipitation forecast is necessary, but result of precipitation forecast will change considerably even when the initial forecast value changes slightly. The ensemble forecast provides explicit precipitation forecast. The ensemble forecast evaluates the stability of forecast results by changing initial values for calculation, and has been practically used in forecasting the course of typhoons. The Meteorological Agency is also considering the provision of precipitation data based on the ensemble forecast.

Figure 2 is an example of runoff calculation using the ensemble forecast precipitations by 20 members. Each line represents the n-th forecast result at each time, red line shows the tenth line, and black line shows actual water level.

Since forecasts contain uncertainties as described, it is essential how to use them in practice while aiming to improve accuracy.

4. Literacy

Technologies addressing the new issues are provided by the individual fields where solutions are studied (e.g., disaster prevention engineering, river engineering for the former, and soil engineering, structural mechanics, concrete engineering, and information engineering for the latter).

A technology will be meaningful only when it is implemented in society. Many relevant technologies have reached the "last one mile," which includes the issue of accuracy.

Future technical development is expected to produce new information, e.g., the information containing uncertainties as mentioned above. To make the best use of such information, it is necessary to enhance literacy (ability to read/write and elicit and use information from given material or ability to apply them -- definition by Digital Daijisen).

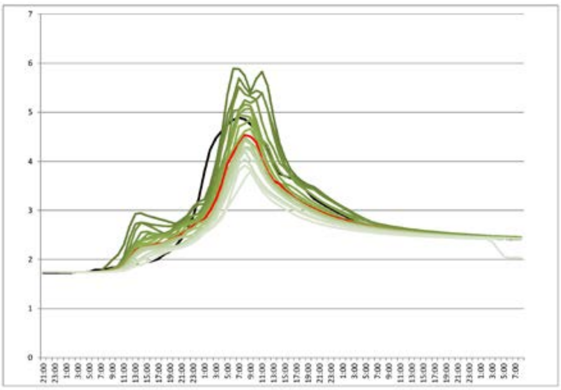

Figure 2: Processed the data of the image of forecast water level based on ensemble forecast precipitation (horizontal axis: time, vertical axis: water level) [2)]

Significant findings cannot be obtained without stepping into the issue of literacy development in addition to technical development. The issue of literacy pertains to individuals and organizations. It is therefore necessary to extend the area of our research activities to organizations and individuals who use the technologies.

Close connection of individual fields and different fields (e.g., organizational science, behavioral science, psychology, sociology) is expected to realize future growth of society.

☞See the following for details.

1) Inazaki, T (2013): Ground Truthing and Integrated Geophysical Surveying for the Safety Assessment of Dike Systems, Proceedings of the 19th Near Surface Geoscience, 4p. DOI: 10.3997/2214-4609.20131350

2) KAWASAKI Masao, INOMATA Hironori (2015) "For Extending Forecast Lead Time in Flood Forecast --- Probabilistic Flood Forecast using Ensemble Forecast" NILIM Report 2015, p.54