

# For Safety Evaluation of Dams with Application of Risk Analysis Method

(Study period: FY2014 to FY2016)

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## 1. Introduction

There have been no serious problems with safety for the dams under the control of the Ministry of Land, Infrastructure, Transport and Tourism since their safety and functions are totally secured by safety management including design based on various technical standards, construction based on strict quality control, daily / periodic / extraordinary inspections and tests including various measurements. However, there are various risk factors concerning the safety of dams, including prospective effect resulting from slight deformation caused by use over a long period and effect of change in the probability of a large-scale flood due to a large-scale earthquake or climate change that is feared to occur in future.

In order to secure and maintain the safety level of individual dams properly with the limited financial resource, the process of risk management would be effective that determines the levels and priorities of reasonable countermeasures considering the aforementioned various risk factors and the condition and characteristics of dams. However, such process requires clarification of the factors (events) that constitute risk and their relationship (risk structure).

## 2. Study on risk analysis method for dams

Then, we studied on application of the event tree analysis for the purpose of identifying various risk factors and events and clarifying their relationships in order to establish a risk analysis method required for risk management of dams. This method visualizes the progress mechanism of events from the event that could be the first risk factor (starting event) to the final event (e.g., instability of the dam body). Further, if the probability of occurrence of each event can be estimated, it will also become possible to evaluate the risk of dams quantitatively. In this study, we first investigated the events of deterioration etc. reported in domestic dam inspections as well as some cases of accidents and disasters in foreign countries, identified risk factors (events) in broad range, and organized them according to the items including type of dam structure and action of external force that can be a starting event (initial flooding, flood, earthquake) (Table 1). We also estimated the factors of the present event of deterioration of the model dam. Then, we organized, with the event tree shown in Figure 1, the progress mechanism of the events that can be expected when action of external force etc. in future can

eventually result in the instability of dam body. It was found through this study that the event tree analysis is effective in clarifying various risk factors concerning the safety of dams and risk structure based on their linkage.

| Dam type                | Starting event   | Indirect cause (Factor)                                       | Chain event 1  | Chain event 2  | Chain event 3                 | Chain event 4                                    | Chain event 5      |
|-------------------------|------------------|---|--|--|-------------------------------|--|--------------------|
| Concrete (Arch type)    | Initial flooding | Inappropriate water stop structure                            | Water leakage in the abutment foundation   | Crack in the arch  | Damage to the concrete        |  |                    |
| Concrete (Gravity type) | Flood            | Insufficient sealing and horizontal layer                     | Inflow more than discharge capacity  | Unplanned overflow   | Rise in uplift pressure       | Sepuring of the foundation at the downstream end | Block sliding      |
| Earth                   | Flood            | Proven with the water stop design of the permeable foundation | Rise in reservoir level  | Increase in hydraulic gradient   | Seepage failure               | Subsidence of the dam                            | Unplanned overflow |
| Rock-fill               | Earthquake       |   | Mobilization of the wave-binding filling material of the interior zone near the bottom | Break of the crown and upstream shell by the pressure of the interior zone | Sliding break to the upstream |  |                    |

Table 1: Example for identification of risk factors (events) by case study

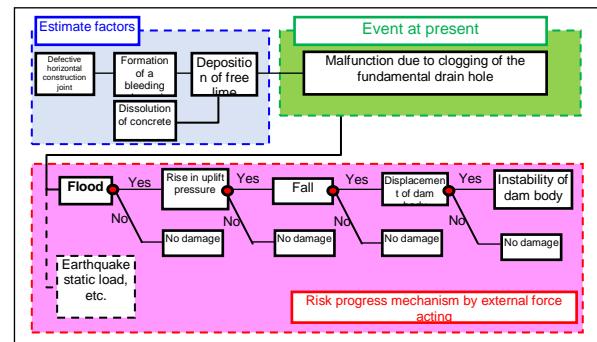


Figure 1: Example for preparation of the event tree for risk analysis

## 3. Future vision

This study is one step for the reasonable stock management of dams based on risk assessment. To realize such management, it is also required to evaluate the possibility of various risk factors and their degree of effect. We also intend to address these issues actively using disaster records and accumulated data on dam inspections in order to achieve practical use of risk assessment.