A GATE OPERATION METHOD FOR
DAMS WITHOUT SUPPORT FACILITY
(A Dam Operation Method Using Only Reservoir Water Table)

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DO YOU/YOUR ORGANIZATIONS FACE THE FOLLOWING ISSUES?

(1) There are a lot of earthdams with spillway gates, but no budget to build an operation support system that measures/calculates inflow, discharge etc. and guides gate operators how to do when floods come.
(2) There is in short supply of experienced experts/engineers for dam operation.
(3) Due to lack of experience, dam operators sometimes have caused very rapid discharges that brought on serious damages of human and asset to the downstream. Namely, the dam operations have caused human-made disasters.
(4) Dambreaks by poor operation have happened due to top dam overflows.
(5) Dam operation rules and regulations define the reservoir water levels or rules to be kept with but they have no description for how to do to achieve them.

WHAT IS THIS METHOD USEFUL FOR?

(1) Dam operator may operate easily and effectively with using only reservoir level and diagrams already prepared based on the actual rules and regulations of dam operation and the hydrological and hydraulic features of reservoir, its catchment and downstream river channel.
(2) Rapid discharges will be avoided and anybody who operates will have the same result. Namely, it does not require any skill or experience of the operators. Therefore, the operators will have not any mental stress due to dam operation.

AN EXAMPLE OF DIAGRAM USED TO OPERATE SPILLWAY GATES

Figure 1 shows an example of the method (herein, we call as Imamura method) used in the case dam has no operation support system, namely, using only reservoir water level with its diagram to operate spillway gates.

The main gate operation to large floods may be sepetated into the following four stages: (1) Pre-flood regulation stage, (2) Flood regulation stage, (3) Pre-emergency stage and (4) Emergency stage. The diagram is used to operate for the four operation stages as follows:

-Pre-flood regulation stage-

Role and difficulty: The crucial roles of this stage are (1) Not starting flood discharge too early to avoid waste water discharge, and (2) Not delaying the appropriate timing to start to flood discharge to avoid afterward having to implement very rapid flood discharge so the users of downstream river have no enough time to evacuate from its river water level increase due to the flow discharge from the dam. Because these two roles conflict with each other, it is difficult to determine the appropriate timing to start flood discharge.

Solution:

-The light blue vertical line in Figure 1 shows the stage of water supply (domestic and irrigation or power generation), the supply flow is always constant.
- The black dashed curves show the candidate relationships between discharge and reservoir water level (herein call the Q_o-H relationship) of dam operation, namely, each curve of them defines the flow to discharge for corresponding reervoir water level, in the Pre-flood regulation stage.

- The timing to start flood discharge is the time the operation transfers from water supply stage to Pre-flood regulation stage, namely, transferring from the light blue vertical line to a curve of the black dashed curves.

- To define the transfer timing, the reservoir water level increment ΔH in the given time interval Δt will be used. Namely, when the point describing a pair of reservoir water level and its increment, namely (H, ΔH) approaches nearly to one of intersections of light blue vertical line and black dashed curves, the transfer shall be done. In Figure 1, the transfer timing and the Q_o-H relationship after being transferred are respectively described by the point and curve of purple color. By this method, the operation will avoid the very rapid flood discharge and transfer to the Flood regulation stage without delaying.

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**Flood regulation stage**

**Role and difficulty:** The crucial roles of this stage are (1) Not starting the Pre-emergency stage too early in order to positively decrease discharge flowing to the downstream river, and (2) Not delaying the appropriate timing to start the Pre-emergency stage to assure enough time for downstream people to evacuate from flooding and to avoid the top dam overflow that will cause dambreak. Because these two roles conflict with each other, it is difficult to determine the appropriate timing to start the Pre-emergency stage.

**Solution:**
- Using the blue curve to operate spillway gates in the Flood regulation stage.
- The black dashed curve group in the Pre-emergency stage of Figure 1 shows the candidate Q_o-H curves in this stage.
To define transfer timing to the Pre-emergency stage, the reservoir water level increment $\Delta H$ in the given time interval $\Delta t$ will be used. Namely, when the point describing a pair of reservoir water level and its increment, namely $(H, \Delta H)$ approach nearly to one of intersections of the blue curve and black dashed curves, the transfer shall be done. In Figure 1, the transfer timing and the Qo-H relationship after being transferred are respectively described by the point and curve of orange color. By this method, the operation will avoid the very rapid discharge and transfer to Emergency stage without delaying.

Flood control operation stage

-Pre-emergency and Emergency stages-

**Roles:** Avoiding the top dam overflow that will cause dambreak.

**Solution:** Operating with using the orange and red curves of Qo-H relationship.

Pre-emergency and Emergency operation stages

**FOR MORE EFFECTIVE USE OF RESERVOIR STORAGE**

In the case the actual operation rules may be changed or there is a budget to install operation support system, we may propose new rules and systems based on the high-level Imamura method to use more effectively existing reservoir based on our professional experiences.
Figure 1 Gate Operation with Reservoir Water Level

PRE-EMERGENCY OPERATION STAGE:
+ Operate with the orange curve
+ Operate all gates

PRE-FLOOD REGULATION OPERATION STAGE:
+ Water supply with the light blue curve
+ Based on H & \( \Delta H \) to determine the timing to begin the flood discharge
+ After that operate with the purple curve.

Note:
+ H: Reservoir water level
+ \( \Delta H \): Reservoir water level rise in the given time interval (herein 30 minutes)

FLOOD REGULATION OPERATION STAGE:
+ Operate with the blue curve
+ Based on H & \( \Delta H \) to determine the timing to transfer to PRE-EMERGENCY OPERATION

Normal water in Flood Term

Gate openings of spillway No.1

Gate openings of spillway No.2