OPERATION OF SPILLWAY GATES OF MULTIPURPOSE DAM RESERVOIRS DURING FLOODS

DR M R GOYAL
Chairman, Board of Consultants for Ranjit Sagar Dam and Shahpurkandi Dam Projects, Water Resources Dept, Punjab, Chandigarh, India

ABSTRACT

A simple and fool-proof innovative method is outlined for operation of spillway gates of multipurpose dam projects during floods. Use of this method can result in utilization of a substantial portion of flood waters for irrigation and power generation, which would otherwise go waste and create floods down-stream. The method is insensitive to errors in input data and is self-correcting. Its efficacy and benefits over the traditional gate operation method can be assessed by running it in a computer simulation, before implementing the same on any project.

Based on this method, a real-time computer program for Ranjit Sagar Dam reservoir, for the available inflow run-off data of 78 years was run, and it was found that a substantial portion of flood waters could be utilized for irrigation and power generation, and frequency and discharge of spillage could also be reduced substantially.

1. INTRODUCTION

In reservoirs of multipurpose dam projects, usually Full Reservoir Level (FRL) is fixed and any inflow above the FRL, is spilled over by opening the spillway gates. This results in wastage of large quantities of flood waters which could otherwise be utilized for irrigation and power generation. Al- though efforts have been made to utilize a part of flood waters, through flood prediction methods, however, these methods have, by and large, been unsuccessful because a large percentage of meteorological instruments go faulty and even if they work properly, a sufficiently accurate flood hydrograph can rarely be predicted.

In this article, a simple and fool-proof innovative method for operation of spillway gates, has been evolved to utilize a substantial portion of flood waters for irrigation and power generation which would otherwise go waste and create floods downstream.

Based on this method, a real-time computer program for *Ranjit Sagar Dam* reservoir, for the available inflow run-off data of 78 years was simulated, and it was found that a substantial portion of flood waters could be utilized for irrigation and power generation and frequency and discharge of spillage was also reduced substantially.

Formulation of the equation for gate operation requires only three input data:

1. Reservoir Surface Area at FRL
2, Outflow through Spillway Gates for one metre opening when Reservoir Level is at FRL

Time of receding wing of a typical flood hydrograph, from the catch- ment.

2. CONCEPT OF THE INNOVATION

The concept behind the innovative methods for the operation of spillway gates is that the operation should be a function of not only the Reservoir level, but also the rate of rise of the reservoir level. As the rate of rise of the reservoir level depends on the net inflow into the reservoir i.e. the inflow discharge minus the outflow discharge, therefore, the incremental gate opening i.e. the change in gate opening, should be a function of the two variables. As the incremental gate opening will be a small percentage of the total gate opening at the crucial steps, therefore, any error in the incremental gate opening, will not make much difference in the total outflow discharge at that step. For example, if the gates are already 5 metres open and the change in the gate opening required at that step is 0.5 metres, then if there is an error of say 20% in the incremental gate opening due to wrong input data, then the error in the total gate opening at that step would be only 2%. Thus the method proposed herein, is insensitive to any error in the input data. Also any inadvertent error in the operation of gates at some step, will be automatically rectified in the next operations. Thus the innovative method proposed herein, is fool-proof and self-correcting. Moreover, the efficacy of the method, can be tested before implementation, by simulating it in a computer program, for a real-time inflow data available for the project.

3. FORMULATION OF THE METHOD

Let the surface area of reservoir at FRL be A hectares, and rise in the Reservoir Level during the previous interval be r metres per hour. Then during the last one hour, $Inflow - Outflow = A * r$ hectare metres.

Let the time of receding wing of the typical flood hydrograph from the catchment be T hours.

For simplicity, assume that the present inflow is the peak of the presently incoming hydrograph and that the flood would recede in T hours in a straight line manner. (These assumptions will not make any significant error in the resultant output, because the method is insensitive to an error in the input data, as explained above)

Let L be the present Reservoir Level, and the Maximum Reservoir Level required to be reached be M – an elevation somewhat below the Maximum Design Flood Level.

Then the additional water to be released through the spilling gates would be A * (L + Tr/2 − M) hectare metres.

Let $Q\ m^3/sec$ be the discharge through one metre opening of the gates.

Assuming that the additional water is to be released in $T/2$ hours, the increase in the gate opening would be:

$$G_i = \frac{L+\frac{Tr}{2}-M}{0.18QT/A} \text{ metres}$$

OR

$$G_i = K_0(L+Tr/2-M) \text{ metres}$$

where

$$K_0 = \frac{A}{0.18QT}$$

In case G_i turns out to be negative, then the gate opening may have to be decreased. However, in that case M may be replaced by $M' = (M - 0.1)$, in order to avoid unnecessary fluctuations in gate opening. The decrease in Gate opening, $G_d = K_o(M' - L - Tr/2)$ metres.

In case G_d is also negative, then during that step, the gates are not to be operated.

In the case of smaller reservoirs, the gate operation step may be reduced to 1/2 hour or even lower, depending on the size of the catchment.

4. CONCLUSION

The above method has the following advantages over the traditional method of spillway gate operation:

1. Saving of a substantial portion of flood waters for irrigation and power generation.
2. Consequent reduction of floods downstream.
3. The method is in sensitive to an error in input data, and is self-correcting.
4. While planning new projects, the use of this method, may result in lowering the height of dam, thus effecting substantial saving in the cost of the project.
5. Use of this method, may render some of the projects (which are other- wise not feasible due to constraints on the height of dam) feasible due to lower height of dam required.
6. The efficacy and benefits of the method, can be assessed before implementing it on any project, by simulating in a real-time computer program.
7. The spillway gate operation can be made automatic.

To get these advantages, the only extra cost involved will be on raising the height of the spillway gates, by $(M' - FRL)$ metres.