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OPTIMAL OPERATION OF HOABINH RESERVOIR FOR FLOOD CONTROLON HONG-THAIBINH RIVER SYSTEM

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Abstract. In the paper the optimal operation of Hoabinh reservoir for flood control on Hong – Thaibinh river system is presented. The finddings show that in the flood season in 1996 if the operation of gates and outlets of Hoabinh reservoir was made base on the calculated release , the water level at Hanoi would be 12,3 m and the water level of Hoabinh reservoir would be 98 m. So the calculated release from Hoabinh reservoir in August 1996 can be considered as optimal in the mean that the water level at Hanoi can be controlled and the Hoabinh reservoir still have necessary pool for controlling the next floods.

1. INTRODUCTION

Optimal operation of reservoirs system for flood control on Hong – Thaibinh river system is a big and complicated problem. In this article the optimal operation of Hoabinh reservoir for flood control on Hong – Thaibinh river system is considered. A linear programming model developed in [1] is applied here for the case of Hoabinh reservoir. It seems to be that the reservoir operation leading from this study is more optimal than the one performed in the flood occurred in 1996 [1], [2], [3].

2. MATHEMATICAL MODEL

The upstream of the Hong river consists of 3 rivers: Da , Thao and Lo. (Fig. 1)

The flow in Da river contributes a significant part to flow in Hong river (In flood season 1996 the flow in Da river is about 70% total flow in Hong river). So up to now the Hoabinh reservoir plays a very important role in flood control on Hong -Thaibinh river system.

We consider the simple model schematic, which simulate the flow from Tabu to ThaoDa confluence. (Fig. 2)

The Hoabinh reservoir is divided into 2 zones, the lower S_1 and the upper S_2

$$S = \sum_{l=1}^{2} S_l.$$

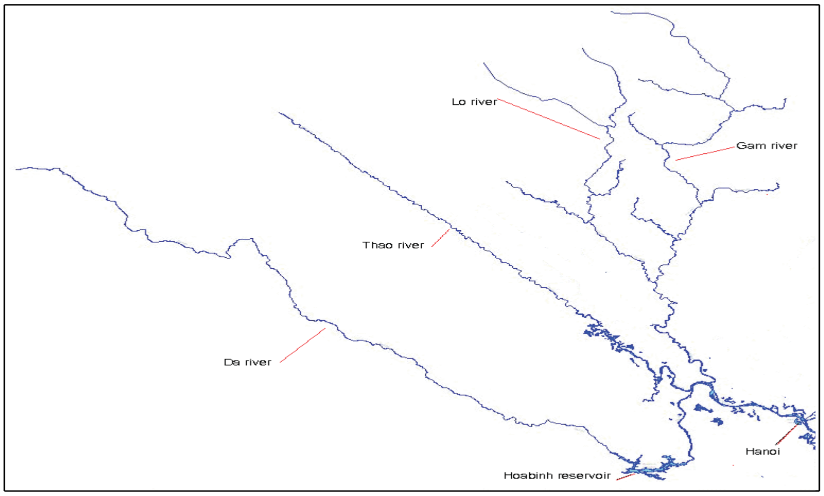

Fig. 1. The upstream of Hong river

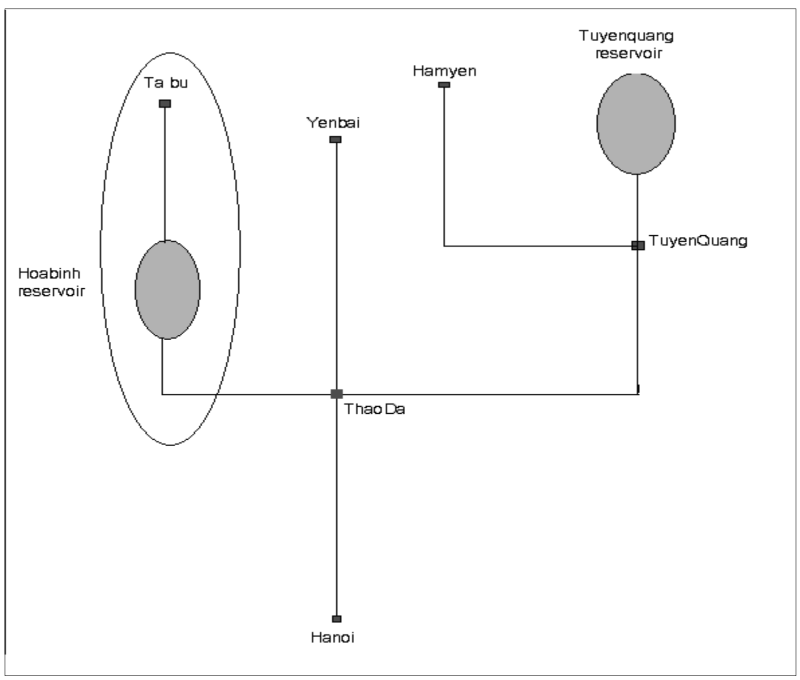

Fig. 2. Model schematic of Hoabinh reservoir

The continuity equation for Hoabinh reservoir and the continuity equation for control at the Thao Da confluence can be written as following: (See [1])

$$\frac{1}{\Delta t}\left[\sum_{l}^{2} S_{i,l} - \sum_{l}^{2} S_{i-1,l}\right] = I_i - f_i \tag{1}$$

$$C_1 f_{i-1} + C_2 f_i + C_3 h_{i-1} - h_i = 0, \tag{2}$$

where Si: storage of l zone of Hoabinh reservoir, I_i: Inflow discharge to Hoabinh reservoir at moment i, f_i - The discharge below Hoabinh reservoir. It is the total release from Hoabinh reservoir, h_i - the discharge at control point at Thao Da, C_i: linear coefficient to route period t flow from Hoabinh reservoir to control point at Thao Da confluence. Ci are found directly from the Muskingum model.

The storage in each zone l of the Hoabinh reservoir is constrained as:

$$S_{i1} \le S_{\max 1}, \tag{3}$$

$$S_{i2} \le S_{\max 2}. \tag{4}$$

In order to sure that storage in zone 1 is filled before water is stored in zone 2, it is necessary to add binary variables and logical constrains:

$$\begin{aligned} &S_{i1} - Y_i.S_{\max 1} \ge 0,\\ &S_{i2} - Y_i.S_{\max 2} \le 0,\\ &Y_i \in \{0,1\}. \end{aligned} \tag{5}$$

The maximum release from Hoabinh reservoir is limited by the hydraulic properties of the reservoir outlet works:

$$f_i \le \frac{1}{2}\beta_1(S_{1i} + S_{1i-1}) + \frac{1}{2}\beta_2(S_{2i} + S_{2i-1}), \tag{6}$$

where: β_l is the slope of the storage discharge capacity relationship in storage zone l.

Finally, the discharge at Thao Da confluence is smaller the discharge that may cause the danger situation for Hanoi.

$$h_i \le h_{\max}. \tag{7}$$

The objective function of the problem is developed by penalty function

$$SP \to \text{Min}, \tag{8}$$

where SP is the penalty function for too much or too little storage outside of a target range of each zone.

For the Hoabinh reservoir the penalty function SP is built as in Fig 3.

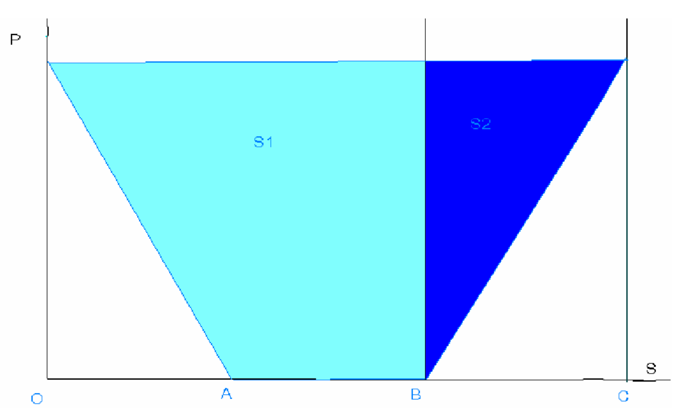

Fig. 3. Storage penalty function

The storage at the point A is the drought pool of Hoabinh reservoir (At the point A water level is 82 m). In the interval OA the penalty function decrease as the storage increase. It is better as the storage in this interval is greater.

The storage from point A to point B is the conservative pool of Hoabinh reservoir, in the interval. AB the penalty function equal zero because the storage change in this interval do not cause any harm for flood control capacity (From the master reservoir regulation manual).

The storage from point B to point C is the flood control pool (At the point C water level is 117 m). The flood control capacity is better in this interval as the storage is smaller. So the penalty function can be supposed linear increase as the storage increase.

In the article we consider the reservoir operation for flood control on the downstream flow , so only the storage S_1, S_2 are used . (S_1: the storage at point B. It is the drought pool plus conservative pool, S_2: the storage from B to C. It is the flood control pool of Hoabinh reservoir)

So the problem can be formulated as following:

With the known inflow I_i to Hoabinh reservoir, find the optimal release f_i from the reservoir in the mean that the penalty function achieve minimum.

$$SP \to min \tag{9}$$

and the constrains (1)-(7) are satisfied

3. OPTIMAL RELEASE FROM HOABINH RESERVOIR

The program developed by the model is used to find the optimal operation of Hoabinh reservoir for flood control on Hong-Thaibinh river system in flood season 1996. It means that with the known inflow to the Hoabinh reservoir in the August 1996, release from the reservoir is found, so that the storage S_2 is minimum and the discharge at Thao Da confluence is smaller the discharge that may cause the danger situation for Hanoi.

For this purpose the following data are used:

The inflow discharge to Hoabinh reservoir in August 1996 (From 7 August to 31 August) (Fig 4.)

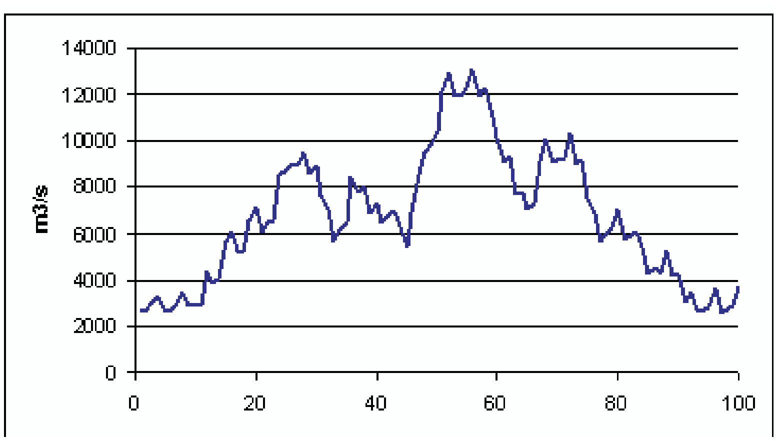

Fig. 4. Inflow discharge to Hoabinh reservoir in August 1996

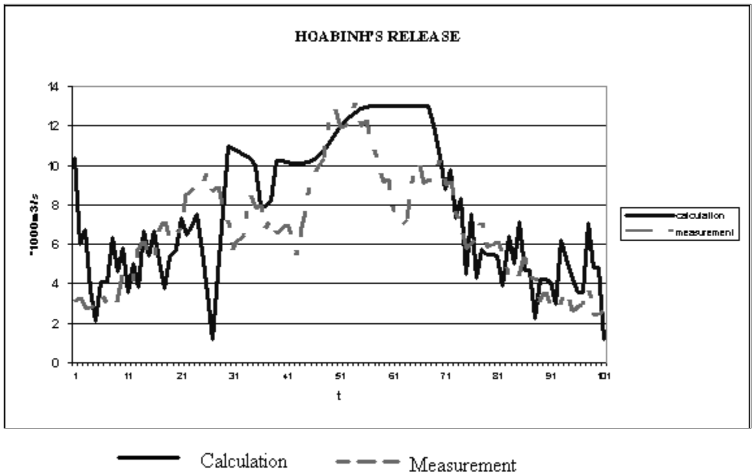

Fig. 5. Measurement and calculation release from Hoabinh reservoir in August 1996

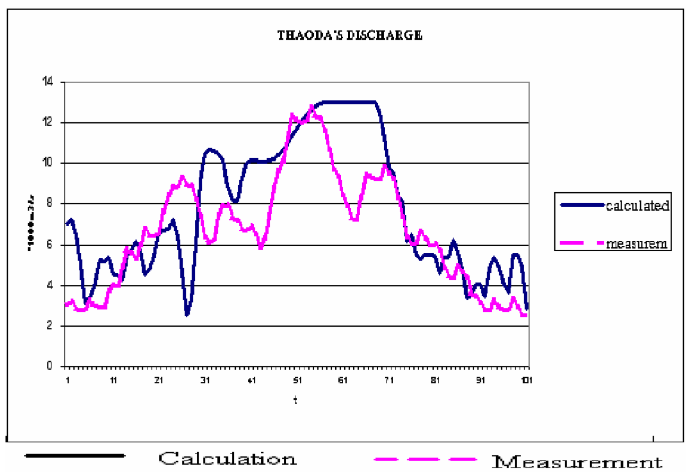

Fig. 6. Measurement and calculation discharge at Thao Da confluence in August 1996

The storage of Hoabinh reservoir:
S_{max1}=6109*10^6 m^3,
S_{max2}=3762*10^6 m^3.

The Muskingum coefficients to flow from Hoabinh reservoir to control point at Thao Da confluence:

$$C_1 = \frac{\Delta t - 2KX}{2K(1-X)+\Delta t}, \qquad C_2 = \frac{\Delta t + 2KX}{2K(1-X)+\Delta t},$$
$$C_3 = \frac{2K(1-X)-\Delta t}{2K(1-X)+\Delta t}, \quad K = \frac{0.5\Delta t[(I_{j+1}+I_j)-(Q_{j+1}+Q_j)]}{X(I_{j+1}-I_j)+(1-X)(Q_{j+1}-Q_j)},$$

where X: coefficient, K: coefficient, Δt: Time step, I_j: Inflow at time step i, Q_j: Outflow at time step i, I_{j+1}: Inflow at time step $i+1$, Q_{j+1}: Outflow at time step $i+1$.

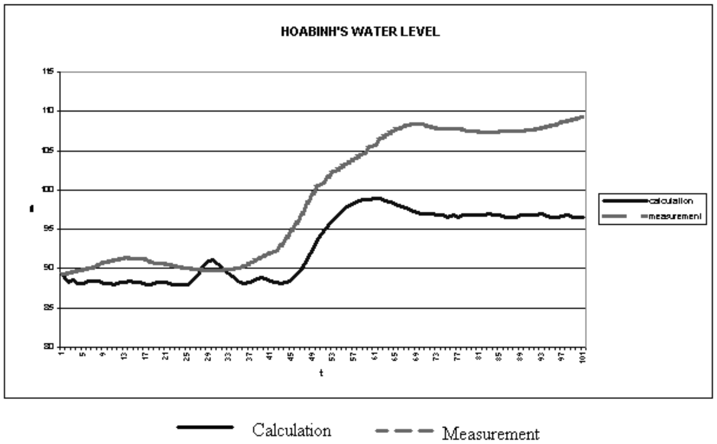

Fig. 7. Measurement and calculation water level of Hoabinh reservoir in August 1996

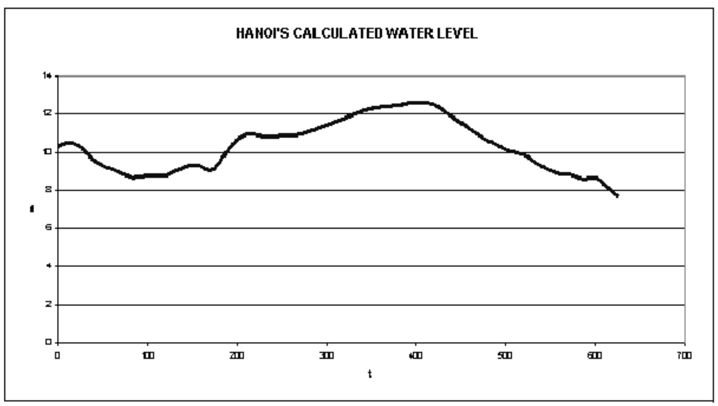

Fig. 8. Calculation of water level at Hanoi in August 1996

The discharge at ThaoDa confluence is not greater than 13000 m^3/s. Calculated result by the model and measurement data for the flood occurred in 1996 are presented in Figs. 5-8.

The measurement and calculation release from Hoabinh reservoir are given in Fig. 5. The measurement and calculation discharge at Thao Da confluence in the Ausgust 1996 are given in Fig. 6. The measurement and calculation water level of Hoabinh reservoir in the August 1996 are given in Fig. 7. By the software I_MECH 1D we see that with the calculated total release from Hoabinh reservoir the water level at Hanoi is not greater than 12.3 m (Fig. 8).

4. CONCLUSION

The findings shows that in the flood season 1996 if the operation of gates and outlets of Hoabinh reservoir was made based on the calculated release, the water level at Hanoi would be 12,3 m and the water level of Hoabinh reservoir would be 98 m. So the calculated release from Hoabinh reservoir in August 1996 can be considered as optimal in the mean that the water level at Hanoi can be controled and the Hoabinh reservoir stll have necessary pool for controlling the next flood.

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ĐIỀU HÀNH TỐI ƯU HỒ HOÀ BÌNH

Trong bài báo này việc điều hành tối ưu hồ Hoà Bình để kiểm soát lũ trên hệ thống sông Hồng Ọ Thái Bình được nghiên cứu. Kết quả chỉ ra rằng trong cơn lũ tháng 8 năm 1996 nếu các cửa xả hồ Hoà Bình được điều hành mở theo lượng xả tính toán thì mực nước tại Hà nội đạt 12,3 m còn mực nước hồ Hoà bình đạt 98 m. Như vậy có thể coi lượng xả từ hồ Hoà bình này trong tháng 8 năm 1996 là tối ưu theo nghĩa là kiểm soát được mực nước ở Hà nội và hồ Hoà Bình còn khả năng kiểm soát các cơn lũ tiếp theo.