

City University of New York (CUNY)

**CUNY Academic Works**

---

International Conference on Hydroinformatics

---

2014

## **Modeling Of Flood Routing Through Stepped Spillway Of Water Reservoir Dam**

Feng Nan

Igor Rummyantsev

[How does access to this work benefit you? Let us know!](#)

More information about this work at: [https://academicworks.cuny.edu/cc\\_conf\\_hic/375](https://academicworks.cuny.edu/cc_conf_hic/375)

Discover additional works at: <https://academicworks.cuny.edu>

---

This work is made publicly available by the City University of New York (CUNY).  
Contact: [AcademicWorks@cuny.edu](mailto:AcademicWorks@cuny.edu)

## MODELING OF FLOOD ROUTING THROUGH WATER RESERVOIR DAM WITH STEPPED SPILLWAY

Nan Feng (南峰) – China

*Work address: Moscow Russia Moscow State University Environmental Engineering*

*Home address: Room 201, Unit 1, Building 19, Jinfengyuan Community, Boshan District,  
Zibo City, Shandong Province, 255200, China.*

*E-mail: nanfeng@yandex.ru*

Rumyantsev I. S. (Румянцев И.С.) - Russia

*Work address: Moscow Russia Moscow State University Environmental Engineering*

### Introduction

The research is dedicated to modeling flood routing through Da Chao Shan Hydropower water reservoir, which is located in Yunnan province on Lancang (Mekong) River [1, 2]. The water reservoir is operating in conditions of rain torrential floods, which can't be forecasted lead time. Therefore we need to consider flood routing through dam in condition of storage water reservoir for Normal reservoir level. Accordingly, the main decrease of maximum discharges and water velocity after dam may be obtained for the account of spillway construction. The modeling of hydrograph of dangerous floods was made with help of HEC HMS technologies on the base of watershed characteristics and with help of modeling storm precipitations of small probability. The observed storm flood of the June 2002 [1, 2] was used for the revision of main parameters of modeling. Then physical model of stepped spillway was made in conditions of laboratory for flood routing through water reservoir dam, which have helped to obtain more accurate parameters for the mathematical modeling. After modeling the water velocities and aeration over the four steps along the stepped spillway face were measured in the dam natural conditions. These were established parameters, which was obtained with help of physical and mathematical models of stepped spillway and flood routing have not a big differences.

### Description of mathematical model

The modeled hydrograph of runoff to water reservoir transformed to hydrograph after dam in lower reach with help of method of approximate integration of Potapov M.V. [5, 6]. The method uses next equations by Zhao J.et al [3].

$$Qdt - qdt = dV \quad (1)$$

$$q = mB\varepsilon\sqrt{2g}H_0^{3/2} \quad (2)$$

Accordingly  $\varepsilon$  is calculated by next formula [3]:

$$\varepsilon = 1 - 0,2 \cdot [\zeta_k + (n-1) \cdot \zeta_0] \cdot \frac{H_0}{nb} \quad (3)$$

$$m_{\text{theoretical}} = 0,385 + 0,149 \cdot \frac{H_0}{H_d} - 0,04 \cdot \left(\frac{H_0}{H_d}\right)^2 + 0,004 \cdot \left(\frac{H_0}{H_d}\right)^3 \quad (4)$$

Here:

$Q$  – water discharge of runoff to water reservoir;

$q$  – water discharge in lower reach of water reservoir;

$V$  – change of water reservoir volume for the time  $dt$  ;

$m$  – the actual values of the coefficients of consumption;

$m_{\text{theoretical}}$  – the theoretical values of the coefficients of consumption;

$B$  – total width of spillway;

$\varepsilon$  – compression coefficient;

$H_0$  – water height over crest of spillway;

$\zeta_k, \zeta_0$  – the coefficient that takes into account the form of foundations and bulls.  $\zeta_k = 0,7, \zeta_0 = 0,3$ ;

$H_d$  – settlement (profiling) head,  $H_d = 0,3$  m,  $H/H_d = 0...1,8, H_0 \approx H$ .

Until today Da Chao Shan Hydropower water reservoir did not work in condition of catastrophic floods with upper level of normal range. Therefore real coefficient of discharge throw spillway ( $m$ ) is not known else for conditions of high levels. Accordingly in the presented work coefficient of discharge throw spillway was researched with help of physical model.

### Description of physical model

Model of the dam together with spillway has been made according to scale 1:60 (figure 3).



Figure 1. China v province Yun Nan built hydro system «Da Chao Shan» [4]

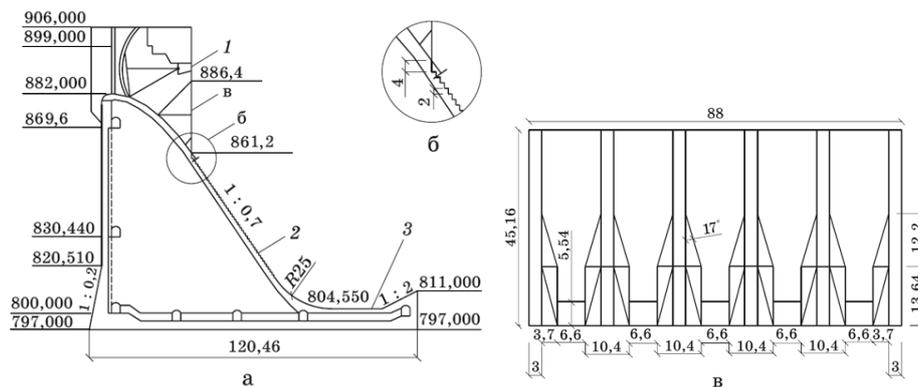


Figure 2. The constructive scheme of the spillway dam of hydroelectric Da Chao Shan [2]: a - cross-section design of the spillway; б - the ledge behind the oxen; в - terminal extension of the bulls in the plan; 1 - bulls; 2 - speed drain face; 3 - jumping-diverter.



Figure 3. Description of physical model

The research gave dependence which is represented on figure 4. Discharge coefficient ( $m$ ) was accepted 0,42 on the base of the model tests (figure 4) according to the research on the physical model respecting of levels upper Normal level of water reservoir. Consequently the obtained coefficient  $m=0,42$  was used in mathematical model for estimation of the routing flood to the lower reach of water reservoir dam.

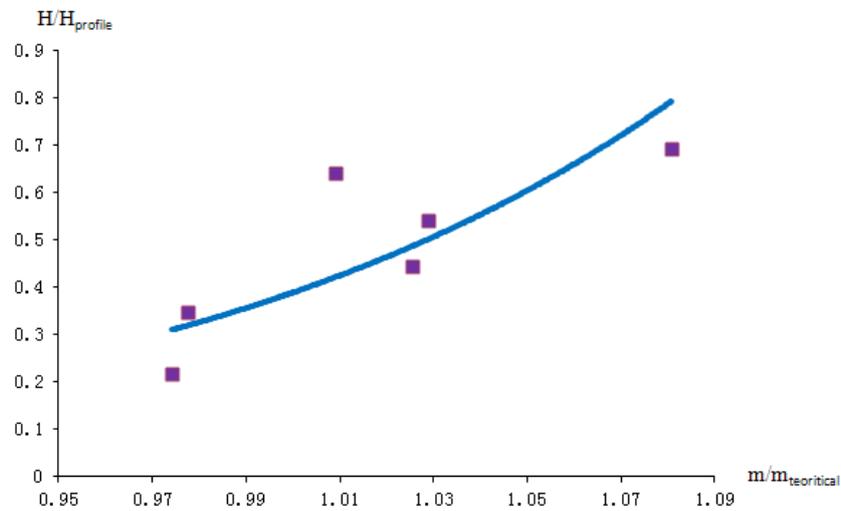


Figure 4. Dependency of the coefficient of the relative discharge -  $m/m_{\text{theoretical}}$  respecting of the relative water height over crest of spillway -  $H/H_{\text{profile}}$  ( $H_{\text{profile}}$  - profiling head).

Hydrograph of draft discharges was calculated with help of the mathematical model (figure 5) [6].

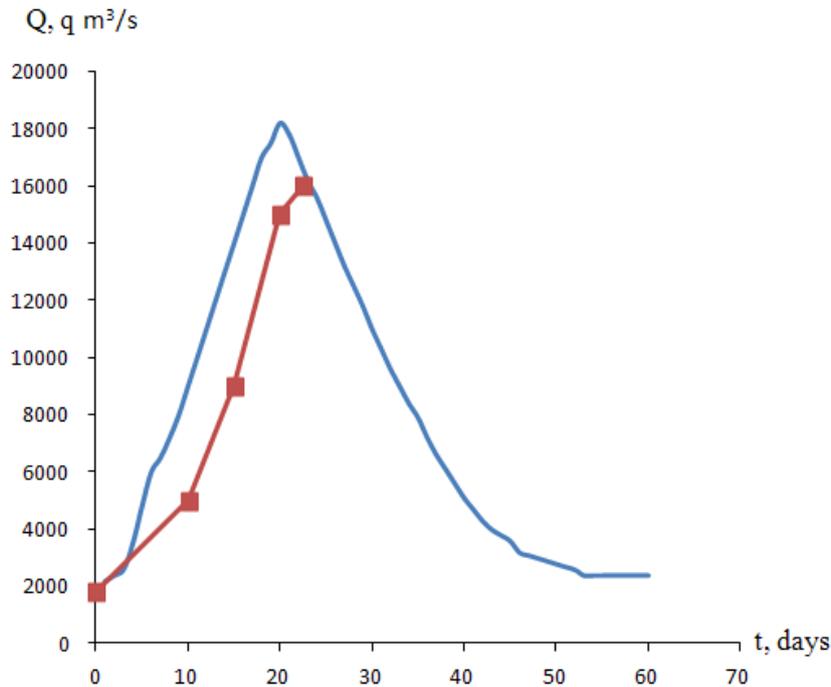


Figure 5. The flood hydrograph scheme, hydrological transformation of runoff  
 $Q_{\max}=16000 \text{ m}^3/\text{s}$

### Conclusions

1. The physical model has allowed confirm the coefficients of consumption (m) in the mathematical model for conditions of high levels in the water reservoir;
2. The obtained hydrograph of draft discharges will allow confirm conditions of velocities and aeration in the lower reach of water reservoir;
3. In modern hydraulic engineering construction of many countries increasingly, disseminating receive the concrete spillway dam with step grassroots drain face. For example, in China at present has already built several tens of waterworks facilities, outlet works which are designed;
4. A new trend for construction of spillway is modernization of structures bulls, arranged on the crests of the latter for control of gates. The essence of this modernization is the expansion unit aft these bulls, mating with toe-ledge. This allows you to: modify the overall picture of current flow in the zone bull; to convert the stream of a two-dimensional to three-dimensional; to sharply intensify the processes of aeration and clearing excess energy flow; reduce the risk of cavitation in areas of hard concrete surfaces bulls and drain grassroots face;
5. Typical parameters of the discharges of the twelve river waterworks China, built and commissioned in recent years, as well as having stepped grassroots drain face.

### REFERENCES

- [1] Jun GUO, Zhiping LIU, Jiguang LIU, Yang LU, Sheng LEI. *Prototype Observation of the Flaring Pier Stepped Dam Face Flood Discharging Hydraulics for the Dachaoshan Hydropower Plant. Yunnan Water Power. Vol 18, No 4. (2002). pp 16–20.*
- [2] Feng Nan. *PRC: Modern structures of concrete spillway dams with a stepped air face. No 1(2013),pp51–53.*
- [3] Zhao J., Zhe J. *Hydraulics .China Waterpower Press. 2007, pp 215–218*
- [4] URL:<http://www.ynjsjl.com/imageRepository/8b00e510-bf1d-4944-b3d0-8b2864a4a15e.jpg>
- [5] Potapov M.V., *Compositions. Moscow, Vol.3 (1951), pp 479 (Rus).*
- [6] Ilinich V., Perminov A. *Regulation of runoff. Moscow, 2010, pp42. (Rus).*