Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 28 (2012) 750 – 753

Procedia Engineering

www.elsevier.com/locate/procedia

2012 International Conference on Modern Hydraulic Engineering

Flood Emergency Management Using Hydrodynamic Modelling

Yongzhi LIU[a*], Wenting ZHANG[b], Xinmin CUI[a], a*

[a] *Nanjing Hydraulic Research Institute, Nanjing 210029, China*
[b] *National Engineering Research Center of Resources Efficient Utillization and Engineering Safety, Hohai University, Nanjing 210098, China*

Abstract

In order to reduce the potential hazard of life and property loss, research on the flood emergency management is very important. A flood impact assessing methodology was proposed and examined in Qingshan reservoir. The key technologies include the flood routing simulation based on 2D hydrodynamic model, and flood losses assessment based on GIS cell. The 2D hydrodynamic model can quickly calculate flood submerged area, flood water depth distribution and flood routing time. The flood information could improve efficiency of flood emergency management and could offer more help in risk indications. The research results provide a powerful tool to analyze flood risk rapidly and make schemes for the flood resisting.

Keywords: Flood risk; 2D Hydrodynamic model; GIS; Emergency

1. Introduction

Due to the global climate change and the rapid urbanization in the floodplains, the frequency of devastating floods tends to be higher and the loss of human lives and property show no sign of decreasing. In order to minimize the impact of floods, an effective flood management is required. Towards this end, hydrodynamic models have a great potential to contribute.

Computer simulation is an important measure about flood emergency management. The Korea Water Resource Corporation (Kwater) which is currently operating and managing 30 large dams, has developed

* Corresponding author: Yongzhi LIU. Tel.: +86-025-85829772
E-mail address: yzliu@nhri.cn.

 doi:10.1016/j.proeng.2012.01.802

a dam safety management system, KDSMS, for consistent and efficient dam safety management [1]. Recent years many administrations in China have developed some flood management decision support systems, focus on flood forecasting, power generation dispatching, flood control scheduling [2,3]. Zhang,etc., developed a Godunov-type coupled numerical model based on one dimensional(1D) and two dimensional(2D) modules to simulate different dam-break flows[4].Under the emergency circumstances, flood risk analysis are very important for making schemes of the flood resisting.

In the last few decades, 1 Dimensional (1D) hydrodynamic modelling has been well developed. It is mainly used for the modelling of rivers, streams and canals. The 2D hydrodynamic model becomes increasingly popular since it could generate apart from the flood extent, also the water depth and flow velocity. The main objective of this research is to develop a procedure for flood emergency management using a 2D hydrodynamic model.

2. Equations and numerical scheme

2.1. Two-dimensional Hydrodynamics Flood Routing model

The module solves the depth averaged 2D shallow water equations (SWE). The SWE are the equations of fluid motion used for modelling long waves such as floods, ocean tides and storm surges. They are derived using the hypotheses of vertically uniform horizontal velocity and negligible vertical acceleration (i.e. a hydrostatic pressure distribution).

The 2D SWE equations are:

$$\frac{\partial h}{\partial t}+\frac{\partial (hu)}{\partial x}+\frac{\partial (hv)}{\partial y}=0 \tag{1}$$

$$\frac{\partial (hu)}{\partial t}+\frac{\partial (hu^2+gh^2/2)}{\partial x}+\frac{\partial (huv)}{\partial y}=gh(s_{0x}-s_{fx}) \tag{2}$$

$$\frac{\partial (hv)}{\partial t}+\frac{\partial (huv)}{\partial x}+\frac{\partial (hv^2+gh^2/2)}{\partial y}=gh(s_{0y}-s_{fy}) \tag{3}$$

Where, h—Water surface elevation.u,v—Depth averaged velocity components in X and Y directions.g—acceleration of gravity.s_{0x},s_{fx}—water surface gradient, friction resistance in X direction.s_{0y},s_{fy}—water surface gradient, friction resistance in Y direction.

2.2. Numerical solution

The three most commonly used numerical methods to solve the SWE are finite difference method (FDM), finite volume method (FVM) and finite element method (FEM).The numerical solution of these equations will here be carried out using (FVM). In FVM method the idea is to calculate water level at the midpoint of each cell and fluxes or velocities are calculated at the boundaries of the cells. The control volume needed in FVM is the volume of each cell. Mass and momentum balances are calculated for every cell.

3. Two-dimensional hydrodynamic model calculation

3.1. Model data

Two-dimensional hydrodynamic modelling studies requires or uses several types of data. This data mainly includes:

- Geographic (location) and topographic (elevation) data.
- Maps and images.
- Land use data (may be extracted from images).
- Boundary conditions.
- Other related data.

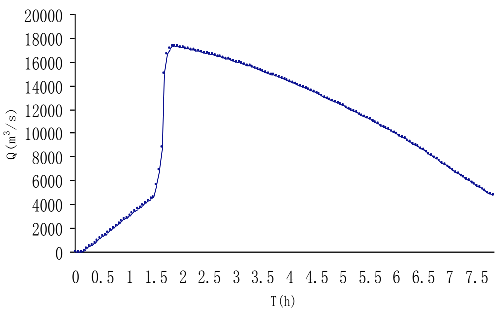
3.2. Model calculation

Model calculation includes the following contents: (1) Determining the calculation area; (2) Mesh generation; (3) Setting model parameters. Before model simulation, the initial conditions, the boundary conditions, and model controlling parameters should be set. Controlling parameters include the calculation of time control parameters, the output control parameter; (4) Model simulation and results analysis.

4. Applications

Locating in middle and lower reaches of South Shaoxi Brook, Qingshan is a large (2) type reservoir for flood control mainly, with purpose of irrigation, power generation and others. Qingshan Reservoir plays a significant role to protect safety of Datang, the dangerous place in the west of Hangzhou City. With total reservoir volume of $2.15*10^8 m^3$, corresponding water level of reservoir 37.20m, Qingshan Reservoir Engineering was started to construct in 1958, completed and put into use in 1973. The hub of reservoir is mainly consisted of main dam, auxiliary dam, spillway sluice gate, water diversion tunnel, hydropower station and other buildings.

The 2D mesh is a structured triangular grid with 4864 elements. There are many reasons could caused dam failure. Overtopping is one of major factors of dam failure. The model can analyze dam break caused by overtopping. Consider overtopping situation, from the dam breach to attain the maximum flow lasted for 1:55:00, corresponding to 19162 m^3/s, then flow gradually decrease, flood process line corresponding to dam break is shown in Fig.1. Flood risk distribution of reservoir downstream is shown on Fig.2.



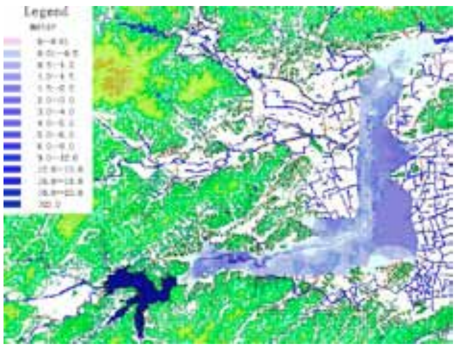


Fig.1 The flood process line corresponding to dam break（1000a）
Fig.2 Maximum submerged range and water depth distribution corresponding to dam break（1000a）

Flood loss is an immediate consequence of flood disaster acting on human activity. Accurately conducting the flood loss evaluation, in practice, can help to make preventive measures for various industries before disasters [5]. Loss of reservoir downstream corresponding to dam break flood is shown in Table 1.

Table 1 Loss of reservoir downstream corresponding to dam break flood(1000a)

Submerged deep(m)	Area(km^2)	Affect population
0.0-0.5	90.6	63570
0.5-1.0	86.7	34750
1.0-1.5	33.2	13510
1.5-2.0	9.7	12450
>2.0	5.2	9090

On the basis of calculation results, the government can timely release warning evacuation orders. And minimize the loss of the lives and property of reservoir downstream.

5. Conclusion

This study shows the applicability of 2D hydrodynamic modelling in flood emergency management. Furthermore, a user-based flood impact assessing methodology was proposed and examined. The 2D hydrodynamic modelling widens the possibility for effective flood emergency management and could offer more help in indicating risk. The research results provide a powerful tool for the analyzing of flood risk rapidly and making schemes of the flood resisting.

Acknowledgements

This work was supported by the National Natural Science Foundation of China (41101510), (41101504); Special Basic Research Fund for Central Public Scientific Research Institutes (Y511004); Chinese University Scientific Fund (2011B04414); and Open fund of state key laboratory of hydroscience and engineering. Tsinghua University (sklhse-2008-A-03).

References

[1] Jesung Jeon, Jongwook Lee, Donghoon Shin, et al., Development of dam safety management system, *Advances in Engineering Software,*2009,40(8), 554-563.

[2] WANG Bing, FENG Ping, Simulation analysis on the emergency flood control operation for the cascade reservoirs, *Journal of Safety and Environment*,2010,10(5),227-231.

[3] ZHOU Wu, LI Duan-you, WANG Tian-hua, Reservoir-Dam Emergency Regulation Technology and Safety Emergency Management, *Journal of Yangtze River Scientific Research Institute*,2009,26(z1),135-139(in Chinese).

[4] ZHANG Da-wei, CHENG Xiao-tao, et al, Numerical model for dam-break flow based on Godunov method. *Advances in Water Science* .2010,(2).167-171(in Chinese).

[5] Zhang Wen-ting, Liu Yong-zhi, Flood Disaster Losses Assessment Based on GIS Spatial Information Cell, *Proceedings of 2010 International Conference on Remote Sensing*,2010, p. 481-485.