Two dimensional simulation of flow around dike breaches

Masih Zolghadr[1], M. Reza Hashemi[2*], M. Ali Zomorrodian[3]
1-M.Sc student of Water Structures, Dept. of Water Engineering, Shiraz University, Shiraz, Iran
2,3-Assistant Professor, Dept. of Water Engineering, Shiraz University, Shiraz, Iran

*hashemi@shirazu.ac.ir

Abstract

Hydraulic simulation of flow around dike breaches is the focus of this study. Due to the actual pattern of flow near the breach, 2-D simulation of flow is inevitable. In this research, MIKE21 is examined to model the flow field around a dike breach. MIKE21 is based on 2-D depth averaged Navier-Stokes equations. The experimental data of a dike breach in the laboratory scale from the previous studies were used to assess the performance of MIKE21. The experimental setup includes a tilting laboratory flume with a length of 10 meters and a width of 0.3 meter. One of the side walls was replaced by two plates in order to create a lateral opening, reproducing the breach. A lateral floodplain was added to the flume letting the outflow propagate outside the breach. The results of this research show that although 2-D depth averaged based flow models like MIKE21 can reasonably simulate the flow pattern near dike breaches but certain numerical capabilities in handling boundary conditions and also for capturing shocks near the breach should be included in 2-D models.

Keywords: Dike breach, shallow water equations, Mike21.

1. INTRODUCTION

Numerous failures of flood protection dikes during floods have been reported in Iran and other countries leading to catastrophic damages. Hydraulic simulation of flow around dike breaches is an important task due to the risk associated with dike failures. Dike failure studies involve hydrological, geotechnical and hydraulic aspects. Numerical models can be used to simulate the pattern of flow around the dike breach which is the main issue of this paper. The pattern of flow around the breach may be used for better understanding of breach mechanism and also prediction of flood wave propagation after the breach. It provides information about the areas to be flooded, flood wave travel time, water depth and breach outflow discharge. Although the pattern of the flow near the breach is 2-D, the majority of current numerical models of river flow simulation such as Mike11 and HEC-RAS are 1-D. Hence, they are not able to simulate the flow around the breach precisely.

Some researches have tried to study 2-D flow around dike breaches; Aureli and Mignosa, in 2001, compared the experimental and numerical results of 2-D flows due to dam and levee-breaking and reported an acceptable agreement between them. The finite difference McCormack explicit shock capturing scheme was used to solve the related governing equation [1]. Aureli and Mignosa also studied flooding scenarios due to levee breaking in the Po River, in 2004. An acceptable agreement between computed results and historical data was found. This demonstrated that the proposed approach was capable of reproducing such cases and leading to preparation of flooding maps [2,3]. Paquier, in 2005, introduced one method to include levee breaching in flood risk assessment. He used a model named CastorDigue which solves shallow water equations to simulate the water flowing out of the breach [4]. Kamrath et al. in 2006 presented a method to calculate flow through a dike breach, and simulated the flood wave propagation. Detailed predictions were made for a number of flood and dike failure scenarios at the Rhine River to evidence the accuracy of this method. The river simulation model, RISMO, was used for analyzing discharge through the dike breach. RISMO also solves the 2-D, depth-averaged shallow water equations in the Reynolds-averaged form using finite element method [5]. Xin et al. in 2007 simulated the dike break flood routing with a 2-D unsteady flow model. This simulation was done according to the characteristics of the dike break flood of the Yellow River. Six different scenarios were taken into account. The input data to the model was composed of field data, typical historical flood data and land use data of the study area [6].

Recently, DHI software such as MIKE11 and MIKE21 are widely used for modeling floods in rivers in Iran and other countries. The objective of the present study is to examine MIKE21 for simulation of flow