

# Review Risk and Threats Due to Dam Break

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**Abstract**—The one of most important objects in implementation of damage analysis observations is manner of dam break wave propagation. In this paper velocity and wave height due dam break in with and without tailwater states for appointment hazardous lands and flood radius are investigate. In order to modeling above phenomenon finite volume method of Roe type for solving shallow water equations is used. Results indicated that in the dry bed state risk radius due to dam break is too high. While in the wet bed risk radius has a less wide. Therefore in the first state constructions and storage facilities are encountered with destruction risk. Further velocity due to dam break in the second state is more comparing to the first state. Hence erosion and scour the river bed in the dry bed is too more compare to the wet bed.

**Keywords**—Dam break, finite volume method, tailwater, risk radius, scour

## I. INTRODUCTION

AM break makes release great volume water, that generate vast flood waves into the tailwater. Whereas sudden dam break creates worst conditions, therefore usually in the dam break modeling this state which investigates damage ultimacy is selected [1]. Via modeling results, arrival time of flood wave to the several points, maximum height of wave with time changes of water level is determine in the downstream of dam, and prepare flood zoning maps in the downstream zones for risk management and crisis control and decrease the damages using this information [2]. As for the high waves velocities, damages in the downstream are too more and warning time is too limited. Therefore dam break object and estimate the velocity and wave height due this phenomenon and thereupon determining of hazardous locations and assessment of damages due to dam failures is noteworthy for researchers [3].

## II. GOVERNING EQUATIONS

The mathematical model used here includes two-dimensional shallow flow equations, obtained by the incompressible flow continuity equation and the momentum navier-stokes equations. Effects of complex turbulence are not entered in the equations [4].

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Shallow water equations in vector and conservation form are as follows:

$$\frac{\partial U}{\partial t} + \nabla \cdot F = S \quad (1)$$

Where Flux vector, including components of E & G:

$$U = \begin{pmatrix} h \\ uh \\ vh \end{pmatrix}, S = \begin{pmatrix} 0 \\ -gh(S_{0x} - S_{fx}) \\ -gh(S_{0y} - S_{fy}) \end{pmatrix} \quad (2)$$

$$G = \begin{pmatrix} vh \\ uvh \\ v^2h + \frac{1}{2}gh^2 \end{pmatrix}, E = \begin{pmatrix} uh \\ u^2h + \frac{1}{2}gh^2 \\ uvh \end{pmatrix} \quad (3)$$

$h$ ,  $u$  and  $v$  respectively: are the depth of flow and the average vertical velocity components along the  $x$  and  $y$  directions.

$g$  = Acceleration of gravity and  $t$  is time.  $S_{0x}$  and  $S_{0y}$ , are the bottom slopes in  $x$  and  $y$  directions, also  $S_{fx}$  and  $S_{fy}$  are the friction slopes in the same directions.

In the model, the slope of friction is calculated by the empirical strength relationships:

$$S_{fy} = \frac{n^2 v \sqrt{u^2 + v^2}}{h^{1.33}} \quad (4)$$

$$S_{fx} = \frac{n^2 u \sqrt{u^2 + v^2}}{h^{1.33}} \quad (5)$$

Where Manning's roughness coefficient. Depth ( $h$ ) and discharges per unit width ( $hu$  &  $hv$ ) are dependent variables that classified in a column vector of  $U$ .

## III. FINITE VOLUME METHOD

The finite volume method is based on mathematical model wherein equations writing in integral form over one control volume. Each control volume that used for discretisation of simulation region is indicated with a cell of mesh. Therefore a

structured grid using quadrilateral cells is used. The boundary of each cell is formed by the four direct walls  $dS_r$  surrounding it. The outward normal vector to each wall is called  $n_r$  [6].

With integrate of equation 1 over the control volume  $\Delta V$  and using divergence theorem one obtains:

$$U_i^{n+1} = U_i^n - \frac{\Delta t}{\Delta V} \sum_{r=1}^4 (F_r^* n_{x,r} + G_r^* n_{y,r}) dS_r + S_r \Delta t \quad (6)$$

in equation 6, numerical flux values  $G^*$ ,  $F^*$  is computed using Roe's method as following [6]:

$$\begin{aligned} F^* &= \frac{1}{2} (F_L + F_R) + \frac{1}{2} [\tilde{A}] (U_R - U_L), \\ &= \frac{1}{2} (G_L + G_R) + \frac{1}{2} [\tilde{A}] (U_R - U_L) \end{aligned} \quad (7)$$

$\tilde{A}$  is the jacobian matrix of  $F$  vector at the vertical direction in boundary.  $n_x$  and  $n_y$  are components of external unit vector in x and y directions.

$$R = \begin{bmatrix} 0 & 1 & 1 \\ -n_y & \tilde{u} + \tilde{c} n_x & \tilde{u} - \tilde{c} n_x \\ n_x & \tilde{v} + \tilde{c} n_y & \tilde{v} - \tilde{c} n_y \end{bmatrix}; \quad (8)$$

$$R^{-1} = \frac{1}{2\tilde{c}} \begin{bmatrix} 2\tilde{c}(\tilde{u} n_y - \tilde{v} n_x) & -2\tilde{c} n_y & 2\tilde{c} n_y \\ \tilde{c} - \tilde{u} n_x - \tilde{v} n_y & n_x & n_y \\ \tilde{c} + \tilde{u} n_x + \tilde{v} n_y & -n_x & -n_y \end{bmatrix}$$

Average values of  $\tilde{h}$ ,  $\tilde{u}$ ,  $\tilde{v}$  and  $\tilde{c}$  are defined as follow:

$$\begin{aligned} \tilde{u} &= \frac{\sqrt{g \cdot h_L} \times u_L + \sqrt{g \cdot h_R} \times u_R}{\sqrt{g \cdot h_L} + \sqrt{g \cdot h_R}} \\ ; \quad \tilde{v} &= \frac{\sqrt{g \cdot h_L} \times v_L + \sqrt{g \cdot h_R} \times v_R}{\sqrt{g \cdot h_L} + \sqrt{g \cdot h_R}} \end{aligned} \quad (9)$$

Subscripts L and R are appertained to the left and the right of the cell interface.

#### IV. RESULTS AND DISCUSSIONS

The dam break problem is shown in Fig. 1. A dimension of channel is 200x200, the breach is 75 m wide and the dam is situated at 1000 m. the initial upstream water level is 10 m and downstream water levels are 5 m and 0 m respectively. In the following, results of dam break in 6 seconds are presented.

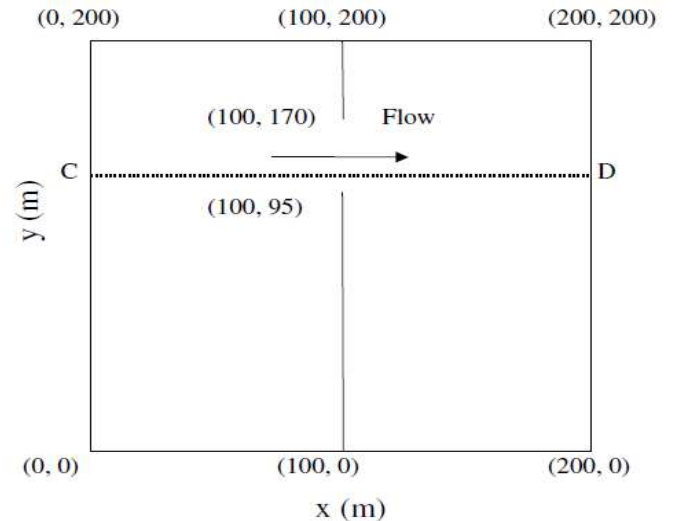


Fig. 1 schematic diagram of 2D dam break problem

Contours of depth in the wet bed state are shown in Fig. 2. As shown in Fig. 2, maximum wave height approximately is 8 m and occurs near 20 m of the downstream. Therefore all of constructions that have less than 7 m height, confronts with destruction hazard. In this state risk radius due flood is too high and the wave is arrive to the 65 m of downstream after 6 seconds.

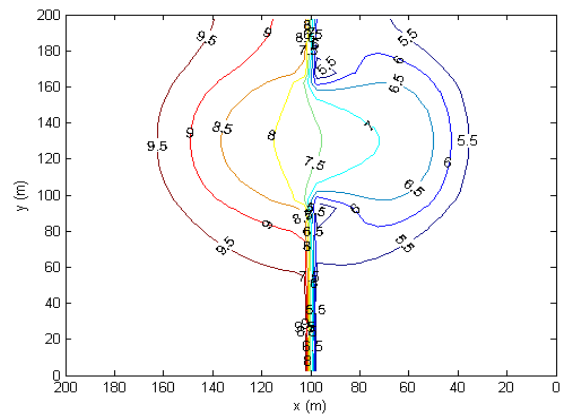


Fig. 2 the contour plots for dam break over wet bed

Water velocity vectors for dam break over wet bed are shown in Fig. 3. At each node the velocity is showed by an arrow, that the value of velocity determined by the length of the arrow. Also according the Fig. 3, maximum velocity occurs in the dam breach range and 20 m of dam downstream. Therefore in this section of channel, scour is occurred. Further as for high waves velocity, possibility of damage to the facilities due to wave strike to those is exist.

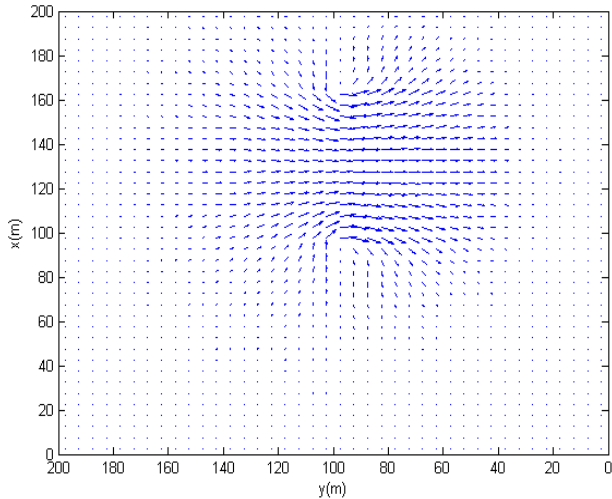


Fig. 3 Velocity vectors for dam break over wet bed

Contours of depth, 6 seconds after dam break over dry bed are shown in the Fig. 4. Maximum wave height in this state is 5 m that occurs in 6 m of dam downstream. In this state risk radius is less wide than previous state, scilicet only the structures and facilities that locates in this radius confront with destruction risk, and the constructions that situates out of risk radius range have a great safety factor.

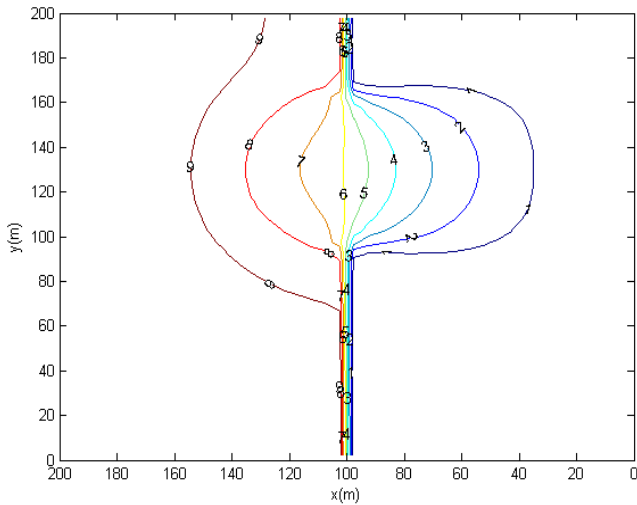


Fig. 3 The contour plots for dam break over dry bed

In Fig. 5 and Fig. 6, water velocity and discharge vectors are shown. As seen in fig. 5, the velocity vectors exist in dam downstream range and canal sides. But in Fig. 6 discharge vectors only occurs in the center of channel and near the downstream the flow is zero. Whereas in the numerical scheme  $uh$  and  $h$  are dependent variables, this discrepancy is creates. This is machine precision that produces finite values for the dependent variable  $u$ , which is calculated from  $u = \frac{uh}{h}$ . But  $uh$  which is a conserved quantity is better value for examine. Moreover this is combination of velocity of flow and corresponding water depth that causes the worse damage.

Therefore, conservative parameters are more important than preliminary variables.

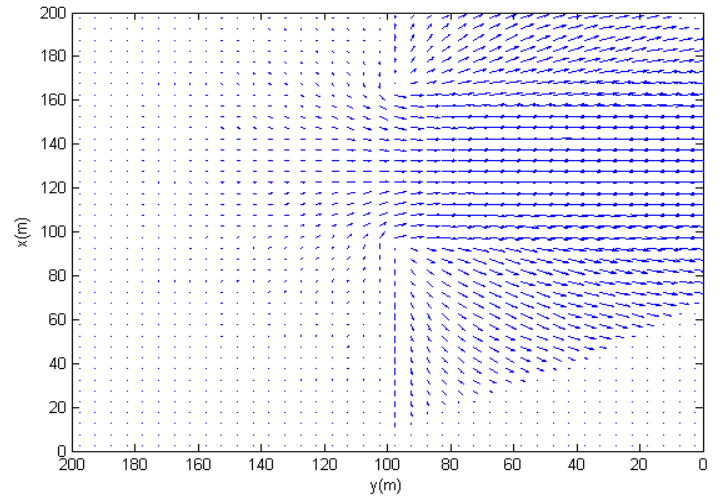


Fig. 5 Velocity vectors for dam break over dry bed

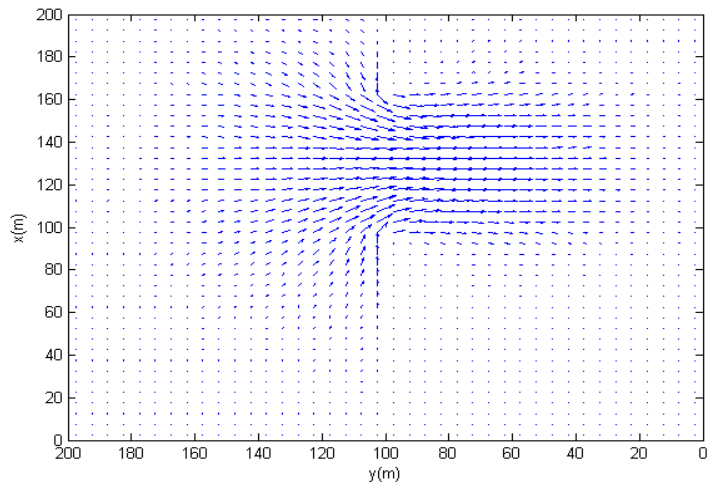


Fig. 6 Discharge flow for dam break over dry

#### REFERENCES

- [1] M., Ghodsian, Dam hydraulics, tarbiat modarres university press, 2003.
- [2] A., zia, a simple and efficient algorithm for dam break modeling, PhD thesis, Tehran University, 2008.
- [3] M. kianian and M.A. banihashemi, 2d model for dam break using fread & McCormack method, M.sc thesis, Tehran university, 2007
- [4] M.H Chaudry, open channel flow, prentice-hall, Englewood cliffs, USA, 2008.
- [5] A. Valiani, A. Caleffi and A. Zanni, finite volume for simulating extreme floeed events in natural channels, JHE, 41(2), pp167-177, 2003.
- [6] A. Shamkhalchian and M.R. Jafarzadeh, investigation of analytical solutions for supercritical flow in bending channels with numerical methods, 8<sup>th</sup> civil engineering international congress, shiraz university, 2009.