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Information technology application of computer simulation in dam collapse construction process

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Abstract

In this paper, two models are established to describe the inundation of downstream floods.Both models adopt a discrete grid approach, treating an area as a grid, and each grid contains the depth and volume of the flood.The complex force model uses the velocity and gravity of the grid and the pressure of the neighboring grid to simulate water flow.The downslope model assumes that the flow velocity is proportional to the height of the water level between the adjacent grids.The downslope model is efficient, intuitive, and flexible, and can be applied to any area with a known altitude.Its two parameters stabilize and limit the flow, but the model's predictions rarely rely on their static values. For Saluda dam break, the total area of flood reaching critical value is 106.5 km^2 ; It hasn't reached the Capitol yet.Lowe Creek's flood waters extended 4.4 miles upstream, covering 1.6 to 2.4 areas

Keywords

Computer simulation, Physical modeling, CAD.

1. Introduction

The Saluda Dam, built between Lake Murray and the Saluda River in North Carolina, could collapse in the event of an earthquake.In this paper, a model is established to analyze the following four kinds of water flow during dam breach and flood:

most be instantly eroded as dam dam moment thoroughly collapse;

The slow erosion of most of the dam is regarded as a complete collapse of the dam after a delay;

Piping is the formation of a small hole first, and finally a crack;

Spillover is a trapezoidal crack formed after the dam is eroded.

All kinds of dam break are described by flow, which is a function of time and corresponding parameters.

2. Model components and analysis

2.1. Reservoir model elaboration

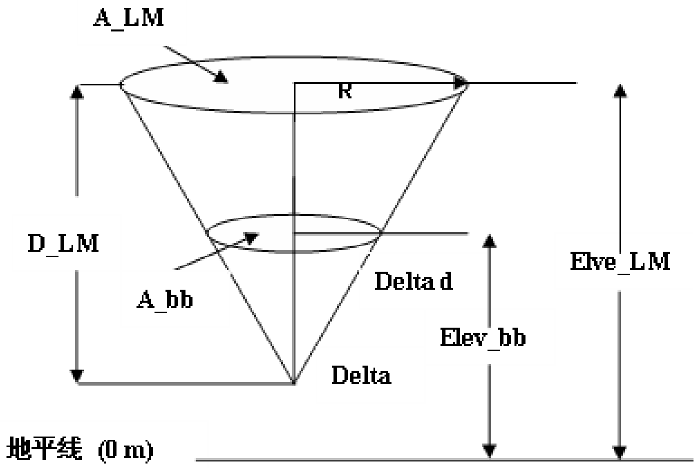

Figure 1: The reservoir is approximately a right cone.

The flow model of instantaneous complete collapse is equilateral triangle.Parameter is the depth of the fracture and the maximum outflow, and its value is

$$d_{breach} = 20\,m, \qquad Q_{peak} = 30{,}000 m^3/s.$$

Using the isosceles triangle model to describe delayed collapse is feasible because it allows half of the total volume of water to flow out of the eroded dam until the maximum flow rate of the burst is reached.In addition, civil DAMS may take longer to erode than other types of DAMS, such as concrete DAMS.This model has the same parameters and has the same values:

$$d_{breach} = 20\,m, \qquad Q_{peak} = 30{,}000 m^3/s.$$

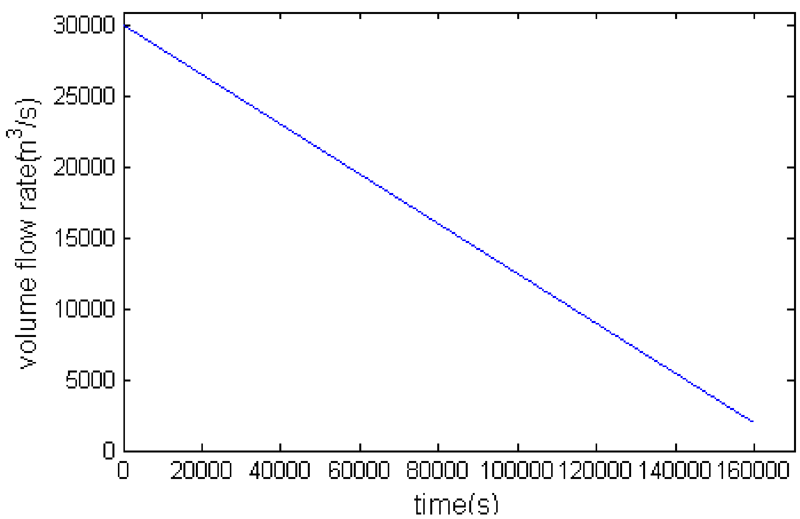

Figure 1: The flow velocity of complete collapse in an instant

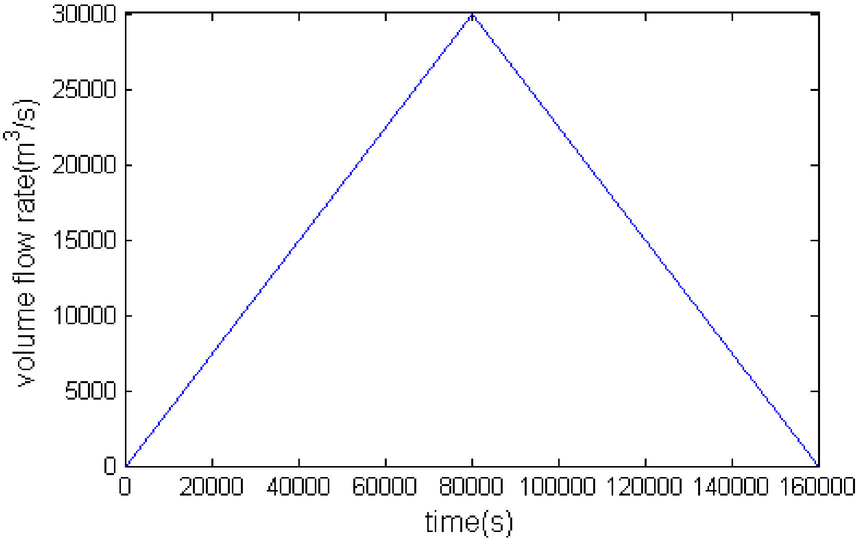

Figure 3 Delay the flow rate of complete collapse

2.2. Analysis of pipeline collapse velocity

In the case of pipeline collapse, the crack first appears in the middle of the dam face and continues to grow until the material on the pipeline completely disintegrates.The velocity increases exponentially due to the increase of the crack.Maximum flow velocity occurs when the material on the pipe is completely disintegrated.From this perspective, the flow of water from the dam to rest during a dam break is analogous to a complete collapse of the dam.We use a decreasing exponential function to obtain different results from the complete collapse model.

We use the growth rate to determine the time when the flood peak breaks, because the flood recedes slowly and the final flow velocity is less than 1% of the flood peak velocity.Taking the depth of the fissure, the flood peak outflow of the dam and the time of the fissure as the parameters, the values are:

$$d_{breach} = 20\,m, \qquad Q_{peak} = 30{,}000 m^3/s, \qquad t_{breach} = 50{,}000 s.$$

In order to better explain the relationship between velocity and time when the crack began to form, we plotted the variation of velocity in a short period, as shown in the figure below:

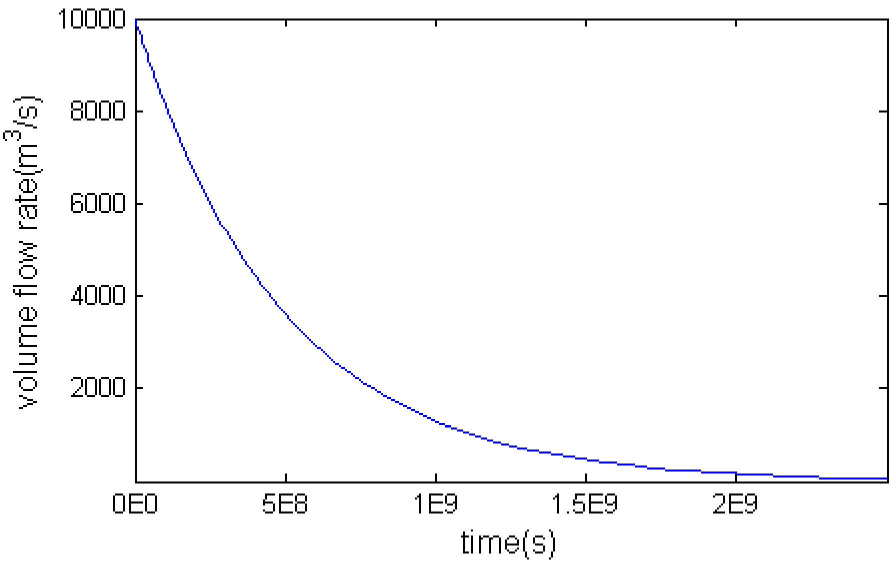

Figure 4 Flow velocity when piping collapses

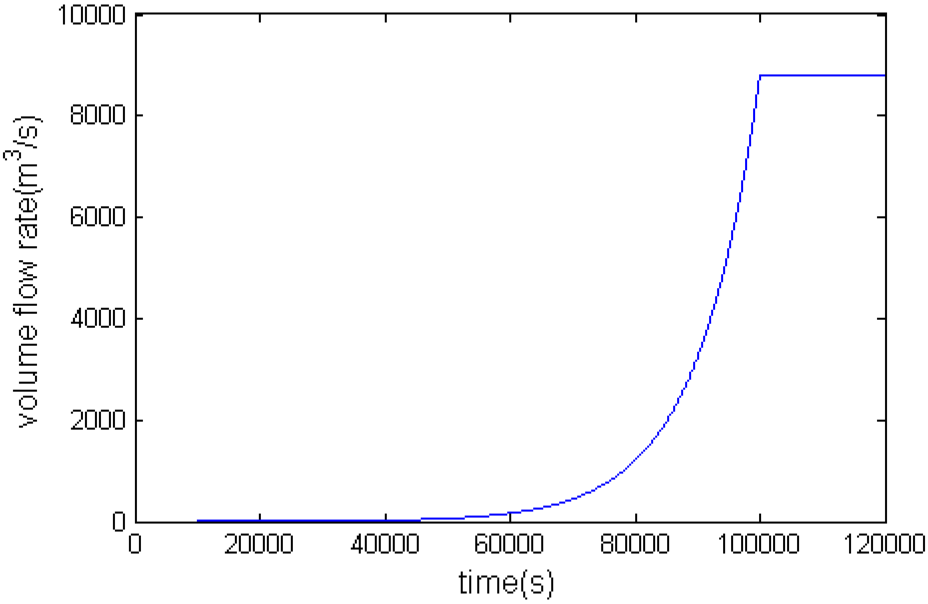

Figure 5 Flow velocity at the beginning of piping collapse

2.3. Flow rate relationship of overflow and collapse

For overflow and collapse, water starts to flow through the top of the crack, which means that it is eroding the dam from above. We found little information about overflow and collapse. In the piping failure, based on the shape of the parabola, we estimate that the flow velocity increases until the dam is completely eroded (Figure 6). After reaching the crack time, it is considered that the flow is equal to the size of the complete collapse state.

Parameters are still the depth of the crack, the peak of the dam outflow, and the time of the crack, which are:

$$d_{breach} = 20\,m, \qquad Q_{peak} = 30{,}000 m^3/s, \qquad t_{breach} = 30{,}000 s.$$

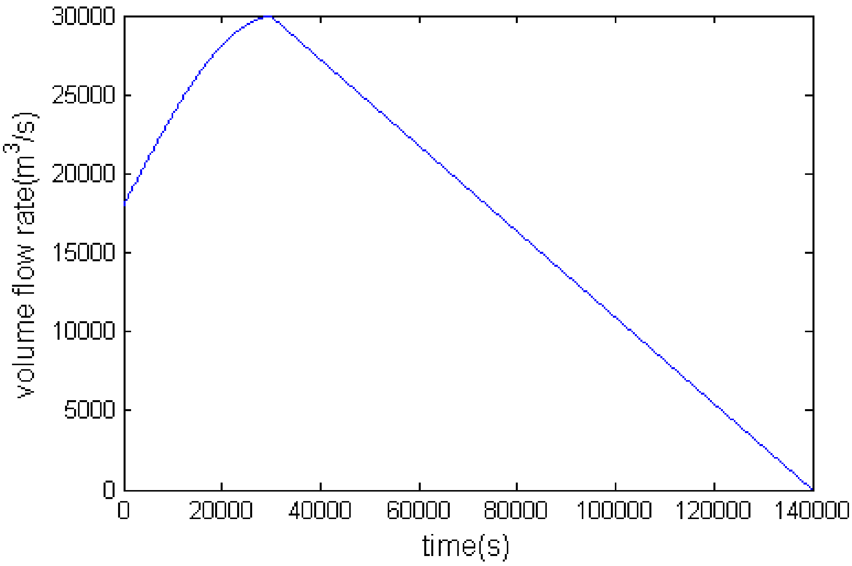

Figure 6 Flow rate of overflow failure

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3. Methods

3.1. Compound force model

This model performs a mechanical analysis of the water contained in the unit. Each unit has an associated altitude, average depth of water, and average velocity (composition). The external force acts on a specific unit, assuming that there are only two effects: the application of external pressure makes the four cells directly contact, and the action of gravity accelerates the flow of water to lower altitudes (that is, downhill).

The main principles of the model are:

The flow rate between the cells is proportional to the different pressures between the four adjacent coplanar cells;The pressure between the cells is proportional to the average depth.As shown in Fig. 7 and Fig. 8, the pressure generated by compressing the element to half its depth is assumed to be the average pressure, denoted as

$$P = \frac{1}{2}\rho g d$$

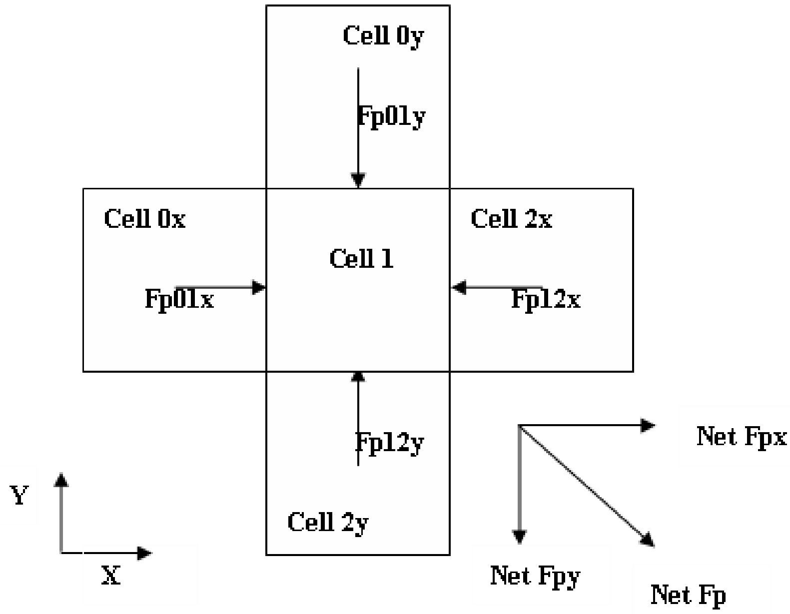

Figure 7 Schematic diagram of the pressure applied to the grid cell

We assume that the pressure applied is the pressure averaged by the depth of compression between the two cells. Since the compression depth of the boundary is averaged, the change in the water depth between them is linear. The pressure applied to the adjacent cells is the average pressure times the area between the two cells.We can find the mass by multiplying the volume of water in the unit by its density, and then divide the force exerted on the water by its mass to find the acceleration of the water:

$$a_x = \frac{g(d_{0x}^2 - d_{2x}^2)}{4\omega d_1}.$$

We estimate the gradient of the current cell and its four adjacent cells and then calculate the acceleration.It is geometrically determined that the horizontal acceleration (Figure 9) is

$$a_g = \frac{2\Delta h \omega g}{4\omega^2 + \Delta h^2}.$$

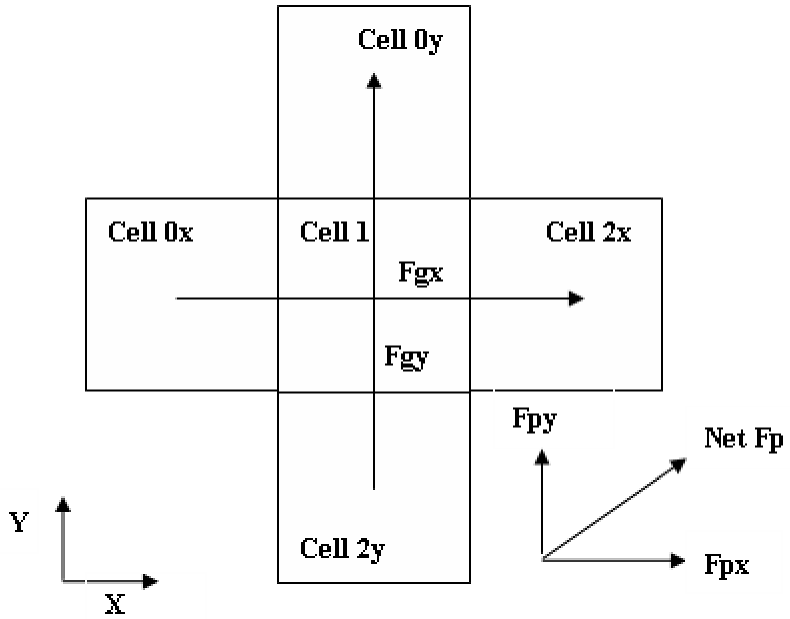

Figure 8 Schematic diagram of gravity applied to the grid cell

Include a large number of time periods in the model, usually in units of 1 second. At the beginning of each period, water flows into the unit including the dam break; the amount of water depends on the dam break model described above. For each time period, the acceleration (composition) is used to calculate the increasing water velocity in each unit in the area, and the water velocity is changed by the following formula, namely:

$$v_{new} = v_{old} + a\Delta t.$$

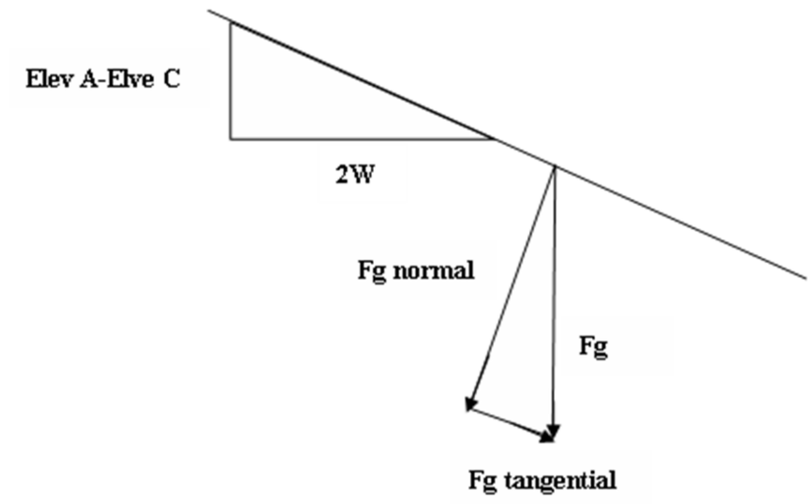

Figure 9 Determine the gravity value down the slope

The speed of the water will determine the direction of the flow of each unit: when, the water in the unit flows to the right;When $v_x < 0$, the cell flows to the left.The amount of water flowing out in that direction is proportional to the velocity, so the current formula for changing the depth of water in grid cells is:

$$d_{donated} = \frac{d_{avg}\Delta t}{2\omega}.$$

The outflow of water changes the depth of adjacent cells, so the total amount of water in the model is conserved (ignoring the water flowing to the edge and injected into the fractured cell).

At very high velocities, a cell can shed more water than it originally had.Specifically, if the velocity times time is greater than the cell width, the outflow will be greater than the current volume of the grid cell.If this happens, suppose that the grid cell loses all its water, and the water loss measured according to the direction marked and can indicate this situation.

3.2. Evaluation

Model features: it uses a simple and meaningful physical analogy to model the state of water. The mechanical analyses used include the use of Bernoulli gradients and the simulation of discrete fluids.

Using computer simulation and saving velocity information can simulate the situation of water in the disaster area. For example, when water hits a particular building in Colombia, such as the State Department, the model can predict the rate at which water will come out.

4. Tests and Conclusions

The extent of flooding is largely dependent on the type of dam breach; Different types of cracks make the flood spread at different rates. For the instantaneous collapse model, the maximum flood area is 106.5km2. The most severely flooded area is the very flat and wide Saluda and Kangarui valleys. There is little chance that water from these valleys will cause flooding in Colombia.So we don't take into account the effects of the flooding coming down from the remote Kangarui Valley, but we want the water to be comparable to the flooding in the simulated area.

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