TRANSPORT EROSION MODEL CALIBRATION USING REAL DAM FAILURES DATA [*]

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INTRODUCTION

During the August 2002 flood in the Czech Republic about 70 small embankment dams failed due to overtopping. The event served to assemble field data for the calibration of numerical dam breach models. Generally the database used to develop breach parameters is quite poor and contains a small number of dam failures when compared to the population of existing embankment dams to which the models are being applied. Therefore the data obtained are of a high value.

MATHEMATICAL MODEL

For the solution, simplified dam breach mathematical model was used. The mathematical model is proposed as one-dimensional initial value problem with unknown functions – breach discharge $Q_b(t)$, breach bottom level $Z(t)$ and reservoir water level $H(t)$. The reservoir area A_s is assumed as constant, the breach is assumed to be rectangular with the width $b(t)$ (Figure 1). The flow rate through the breach is calculated from the broad crested weir formula.

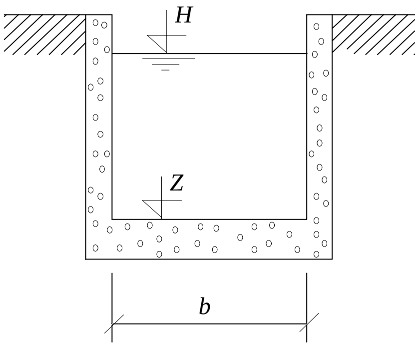

Figure 1. The scheme of the breach opening

The mathematical model consists of the set of four governing equations, namely reservoir routing equation

$$\frac{\mathrm{d}V}{\mathrm{d}t} = Q_{in} - Q_b - Q_f \,, \tag{1}$$

which for constant reservoir area A_s and negligible difference between reservoir inflow Q_{in} and outflow Q_f through bottom outlets and emergency spillway can be written as follows:

$$A_s \cdot \frac{d\,H}{d\,t} = -\,Q_b \ . \tag{2}$$

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The empirical transport formula expresses the rate of the change of cross-sectional area $A_b(t)$ due to erosion:

$$\frac{d\,A_b}{d\,t} = f(v,\alpha,\beta), \tag{3}$$

where v is breach flow velocity and α and β are empirical erosion parameters being the object of calibration. The general transport formula (3) is expressed for vertical and horizontal breach development:

$$\frac{\mathrm{d}\,Z}{\mathrm{d}\,t} = -\alpha \cdot v^2 , \tag{4}$$

$$\frac{d\,b}{d\,t} = \beta \cdot v , \tag{5}$$

The breach outflow discharge is calculated from rectangular broad-crested weir formul, (6) where m is overflow coefficient, $M = m \cdot \sqrt{2 \cdot g}$ and $b(t)$ is the width of the weir. It holds:

$$v = M.(H - Z)^{1/2} , \qquad A_b = b \cdot (H - Z) , \tag{7}$$

After some manipulation we obtain the set of three ordinary differential governing equations:

$$\begin{aligned} \frac{d\,H}{d\,t}(t) &= -\frac{M}{A_S} \cdot b(t) \cdot (H(t) - Z(t))^{3/2} \\ \frac{\mathrm{d}\,Z}{\mathrm{d}\,t}(t) &= -\alpha \cdot M \cdot (H(t) - Z(t)) \\ \frac{d\,b}{d\,t}(t) &= \beta \cdot M \cdot (H(t) - Z(t))^{1/2} \end{aligned} \tag{8}$$

Initial conditions are as follows:

$$H(0) = H_0 ; \quad Z(0) = Z_0 ; \quad b(0) = b_0 , \tag{9}$$

where H_0, Z_0 and b_0 are the initial reservoir water level, the level of the breach bed and the width of the breach flow at the beginning of the breaching (in $t = 0$).

Keywords: dam failure, dam erosion, dam breach modelling, erosion parameters.

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