BREACH EROSION IN CLAY-DIKES

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Devastating disasters may occur in case of a dike failure during floods. However, the magnitude and degree of the damage varies enormously, and depends highly on the process of breach growth, which determines the flow discharge flowing through the breach, and then the inundation speed and the available time for evacuation of people and properties at risk. A dike breach model can predict the breach formation process as well as the breach outflow hydrograph. Therefore such a model can be of tremendous value for a dike failure early warning system and an emergency evacuation plan, consequently also for disaster mitigation, damage assessment and risk analysis, etc. The objective of the present study is to investigate the physics of the breach erosion process in clay-dikes (i.e. dikes constructed with cohesive soil) and to develop a mathematical model for this process.

The whole breach erosion process in clay-dikes can be generally subdivided in 5 stages. During the first stage, the overtopping flow lowers the dike crest and steepens the dike inner slope until a certain critical angle is arrived. Then in Stages II and III, flow shear erosion, dike foundation scour and headcut mass wasting occur and weaken the dike body until the dike is completely broken through at the end of Stage III. For the last two stages, breach erosion takes place mainly laterally. The breach width increases markedly due to continuous flow shear erosion and discrete mass failure from the breach side slopes. The extent of vertical erosion in these two stages relies mainly on the erodibility of the dike foundation, the presence of a toe protection on the dike outer slope and the presence of a relatively high foreland (Visser, 1998). Depending upon these geometrical and material conditions, three types of breaches can be distinguished for Stages IV and V of the breach erosion process in clay-dikes.

Based on this five-stage breach erosion process, a mathematical model has been developed for the breach erosion in clay-dikes. The analytical development of Stein et al. (1993) in jet scour mechanics is utilized in the model to calculate the jet scour of dike foundation. The discrete headcut mass wasting in Stages II and III is simulated through a mechanical method (Zhu et al., 2004). For the last two stages, depending upon the geometrical and material conditions of the dike, different formulae have been provided for the rate of breach growth for the three types of breaches, respectively.

The model has been tested with the data of three laboratory experiments performed in HR Wallingford (Hassan et al., 2004). The agreements between the model predictions and the experimental data are good.

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