ETH zürich

Numerical modeling of embankment breach processes (Project: APUNCH)

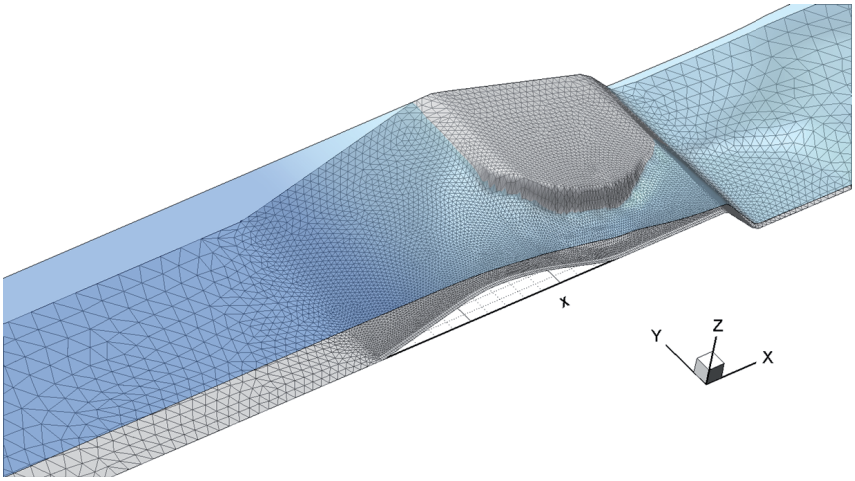

Figure 1: Numerical simulation of spatial dyke breach

Extensive flood run-offs can be caused by extreme rainfall events in Alpine watersheds. Such extreme events jeopardize the stability of natural dams formed by accumulated sediments, of earthen reservoir dams and of river dykes in the lower river reaches. This project wants to analyze the most relevant breaching processes of such embankment breach events with numerical methods.

Hydrodynamic and surface erosion modeling

The 2D shallow water equations and empirical sediment transport formulas are used to simu-late the overtopping of the embankment and to analyze the vertical surface erosion caused by the act-ing stream forces. The vertical surface erosion thereby can take place in form of bed load or suspended load transport. For this purpose the freely available numerical software BASEMENT was applied and further developed.

The model allows the use of unstructured meshes consisting of irregular triangles and quadri-laterals, which allows adaptations to complex and realistic geometries being an

Seepage flow through embankment body

Slope failure modeling depends on the pore pressures in the embankment in the saturated and unsaturated zones. Therefore a modelling of the 3D Richard's equation was chosen, which is capable to simulate the flow in the saturated and unsaturated zones of the embankment. Also it is able to model accurately the infiltration of water into the embankment body. The rather new modelling technique of the Lattice-Boltzmann Method (LBM) was recently adapted to the Richard's equation and was chosen for this purpose. A LBM based model for the Richard's equation is implemented and applied to homogeneous and heterogeneous embankments.

Modeling of slope failures

Slope failures, occurring during the embankment overtopping, often contribute significantly to the lateral widening of the breach channel and therefore must be considered in the numerical simulation. For this purpose a new approach applicable on unstructured meshes is developed. This approach bases on the assumption that slope failures of the steep side walls take place if critical side wall angles are exceeded. These side wall angles are estimated as functions of the pore pressures within the embankment body, the water levels in the breach channel and the material properties.

Keywords:	dyke breach, shallow water equations, bed load transport, suspended load transport, Richard's equation, seepage modeling, Lattice-Boltzmann Method
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Laboratory of Hydraulics, Hydrology and Glaziology
Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie