The History Bandits (2016)

Composite modeling of embankment dam breaching due to overtopping

Matthew Halso

BASEMENT User Meeting 2022

February 3, 2022

Recent dam and dike overtoppings

Mississippi River Dike, Missouri (2019)

Winfield Police Department (2019)

Edenville Dam, Michigan (2020)

Coleman (2020)

Kaleto (2020)

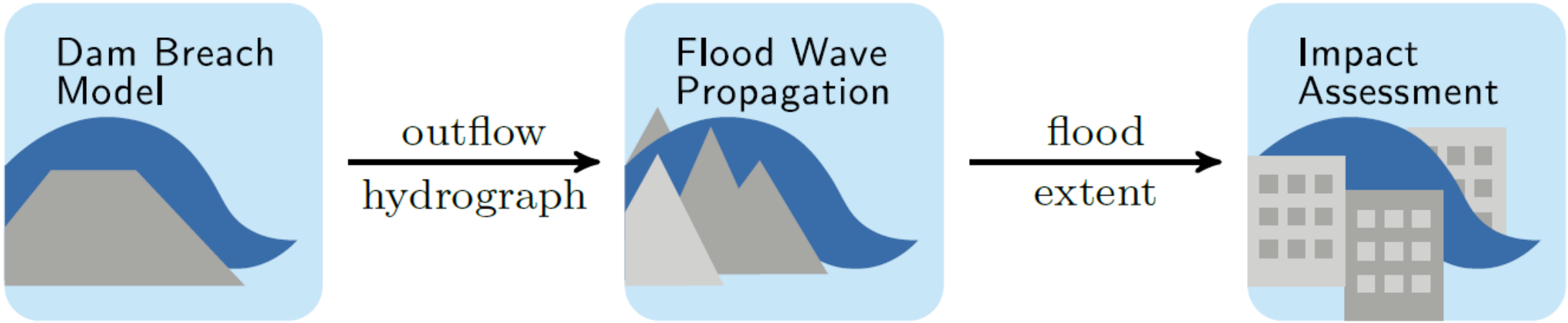
Steinbachtal Dam, Germany (2021)

Agence France-Presse (2021)

Contents

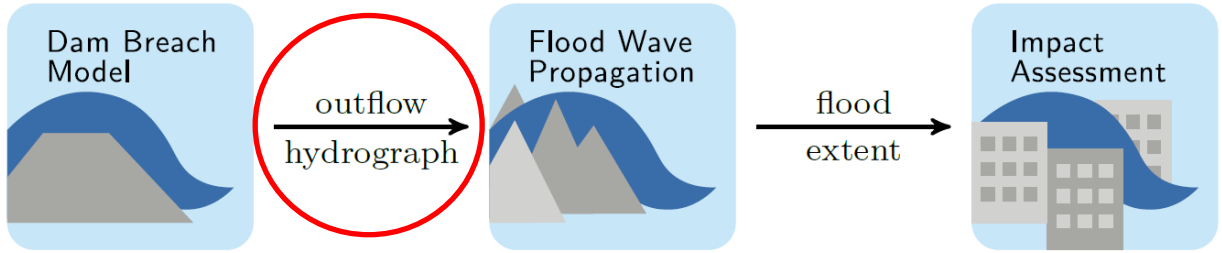
- Steps in a dam breach analysis
- Processes in development of an overtopping breach
- Laboratory experiments of dam breaching due to overtopping
- Numerical modeling of dam breaching due to overtopping
- Research outlook
- Implementation in BASEMENT

Steps of dam breach analysis

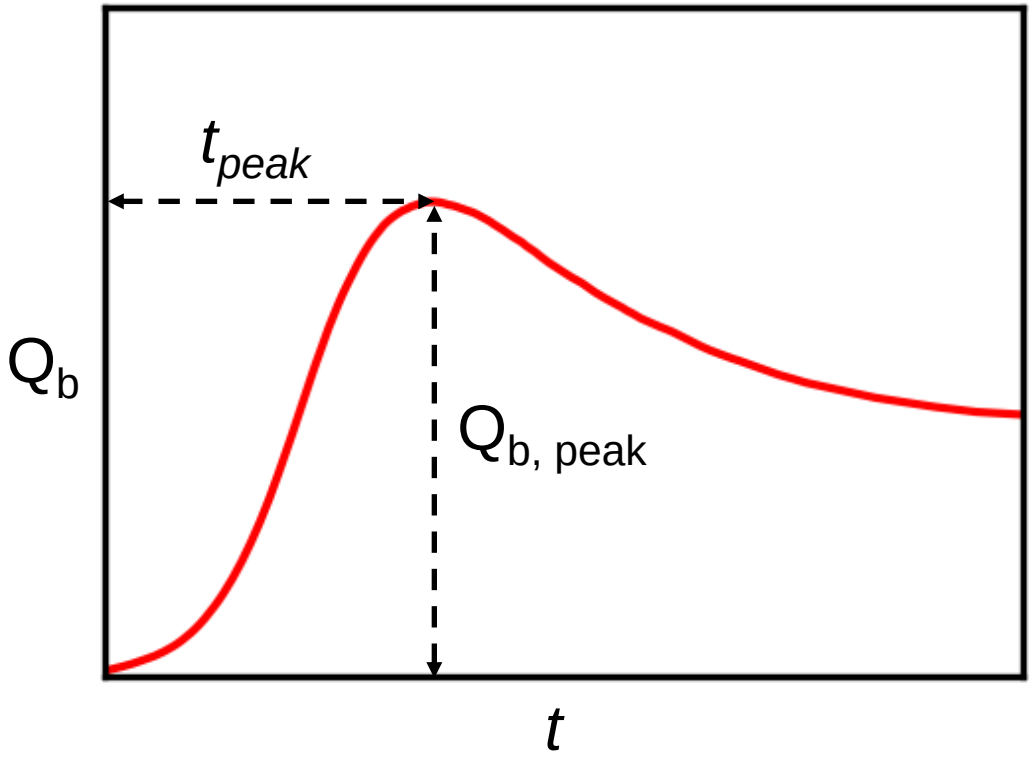


Peter, 2017

Breach outflow hydrograph



$Q_b(t) = f($ material,
geometry,
hydraulics,
etc.)



General progression of overtopping breach

Initial surface erosion and deepening

Horizontal expansion

Reservoir lowering, slower horizontal expansion

California Nevada River Forecast Center (1986)

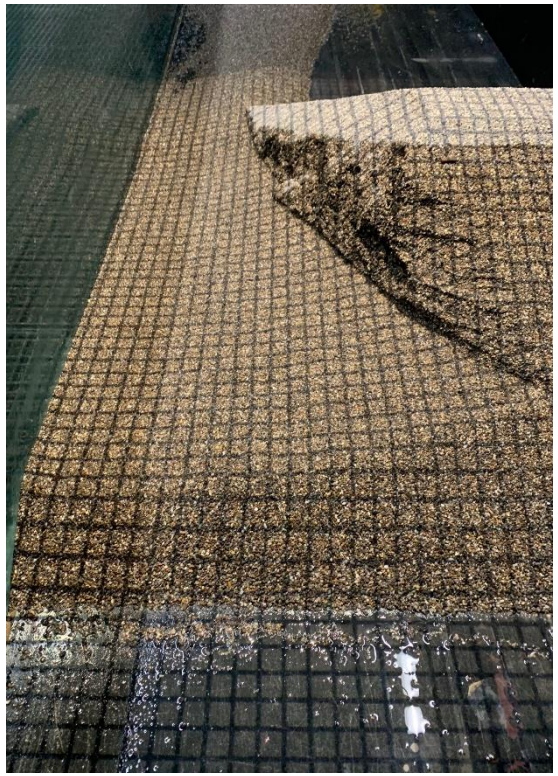
How to determine the breach outflow?

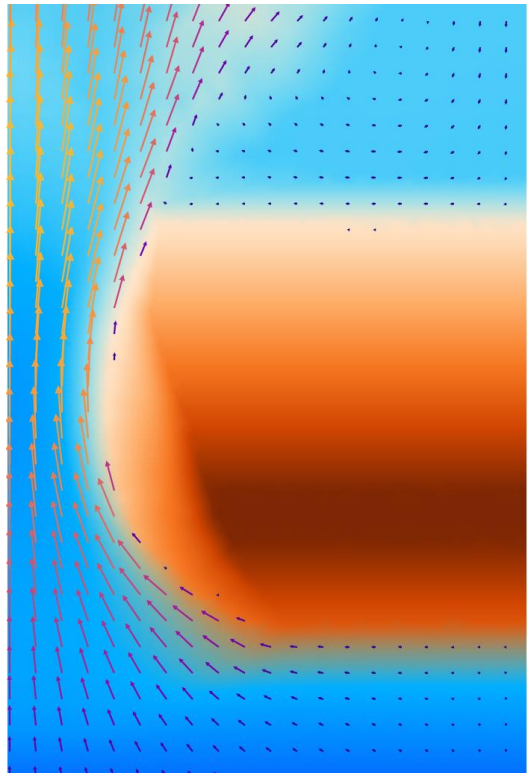
Composite modeling :

Laboratory experiments

+

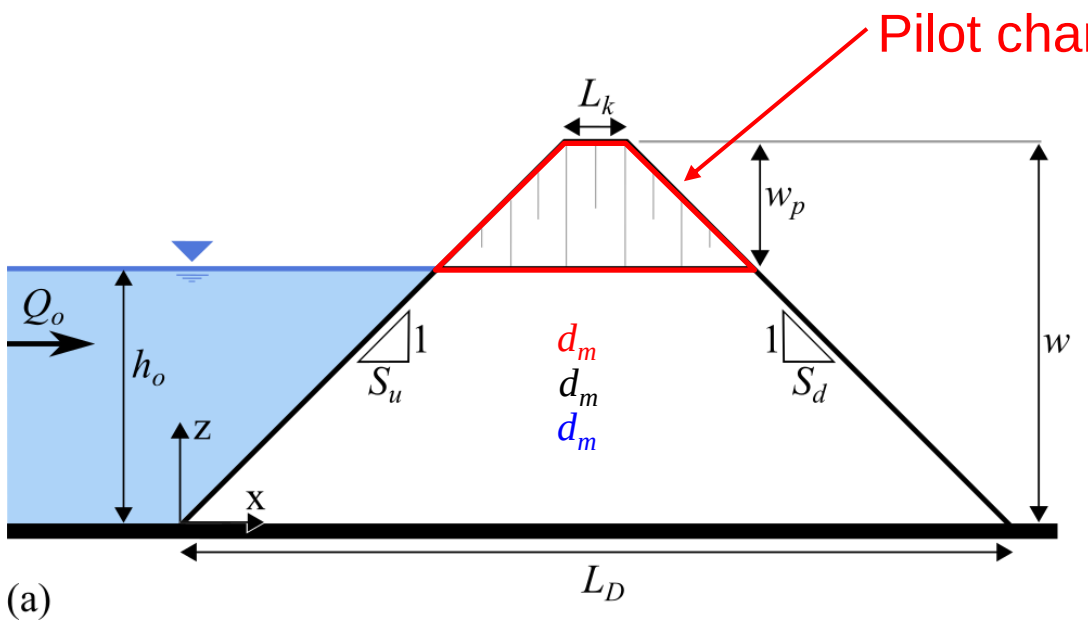
Numerical modeling with BASEMENT



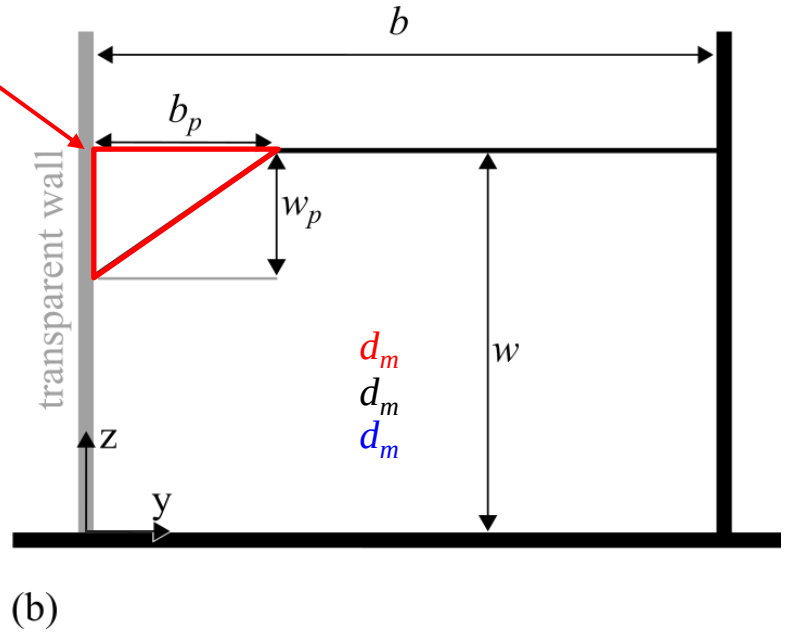


Model embankment dam

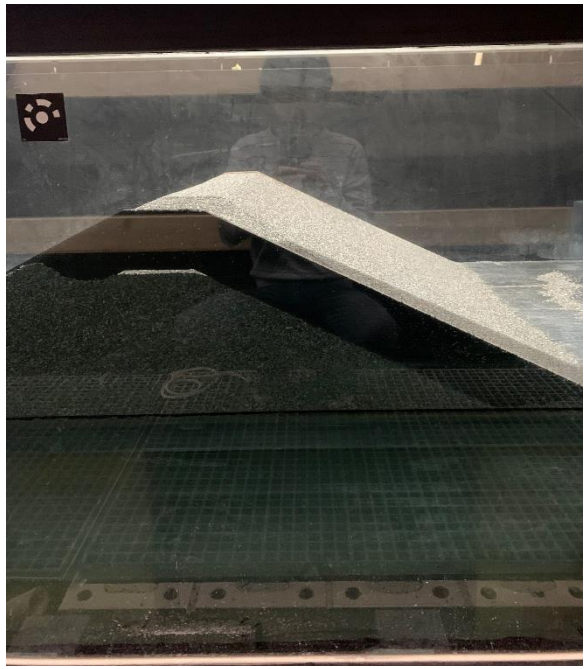
Longitudinal profile

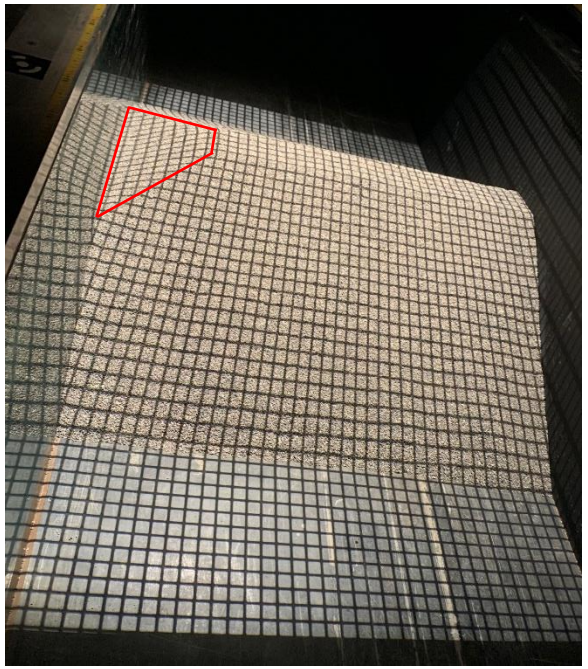


Cross section

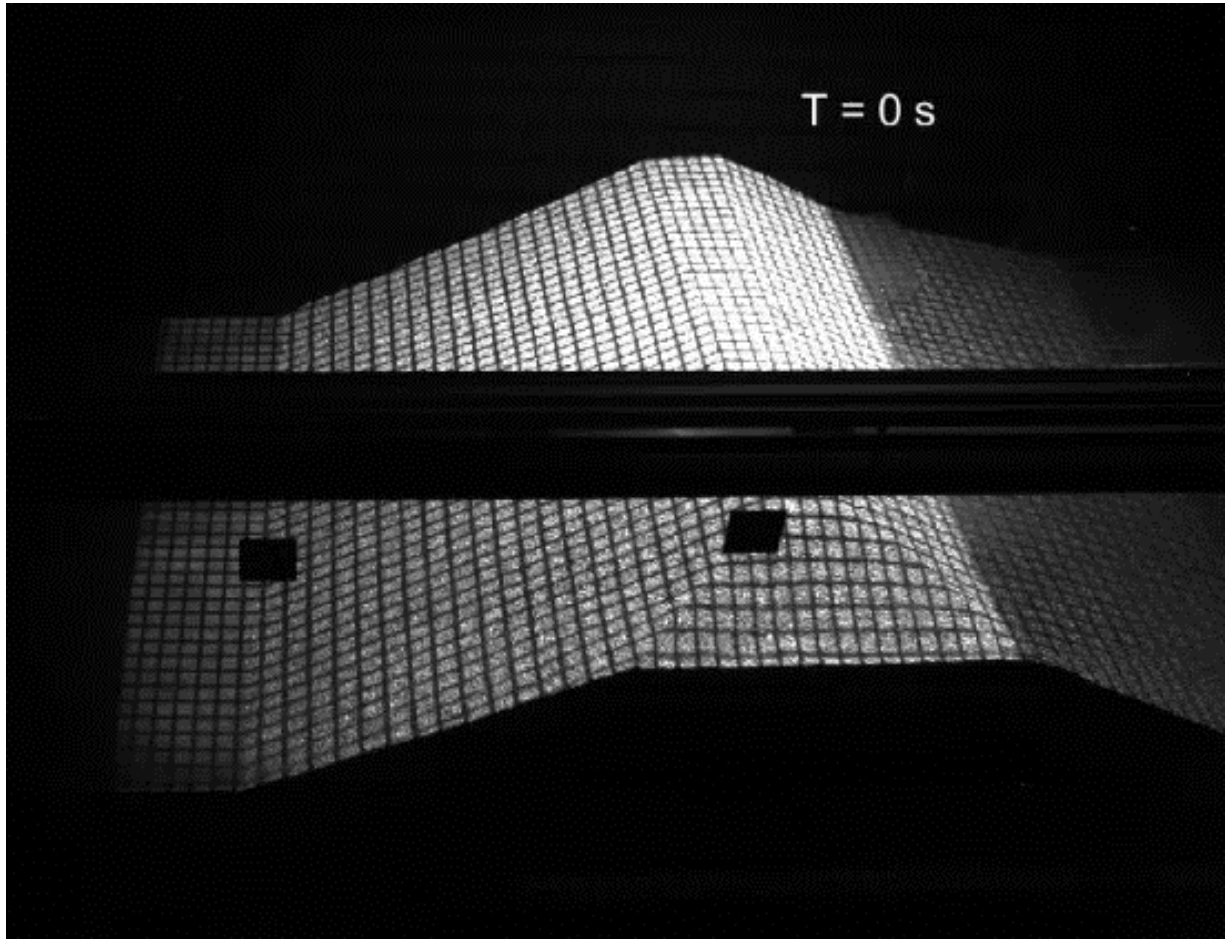


Laboratory experiment: model setup

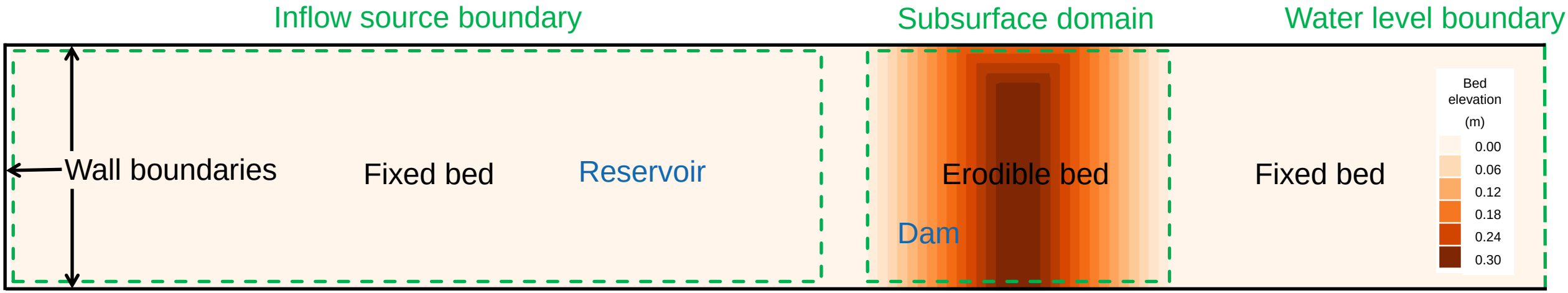




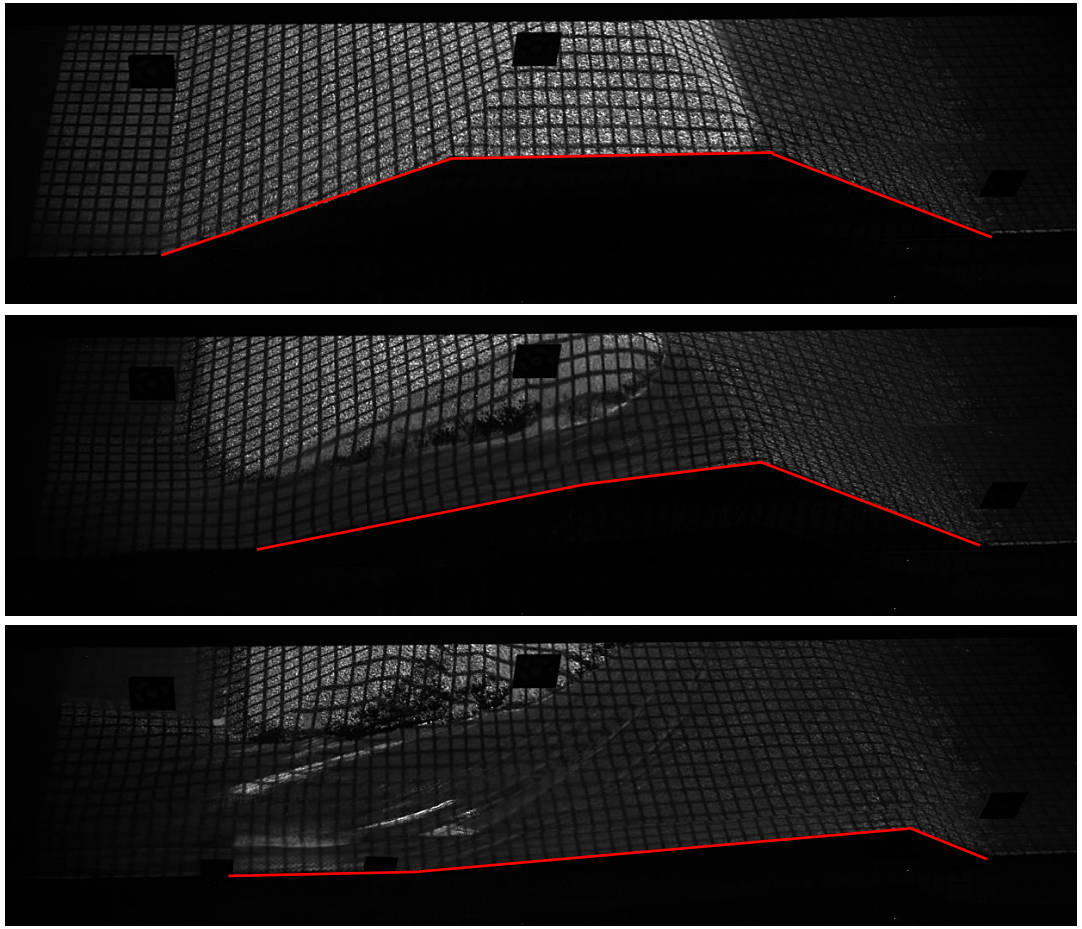
Laboratory experiment: embankment erosion



Numerical modeling: BASEMENT model setup

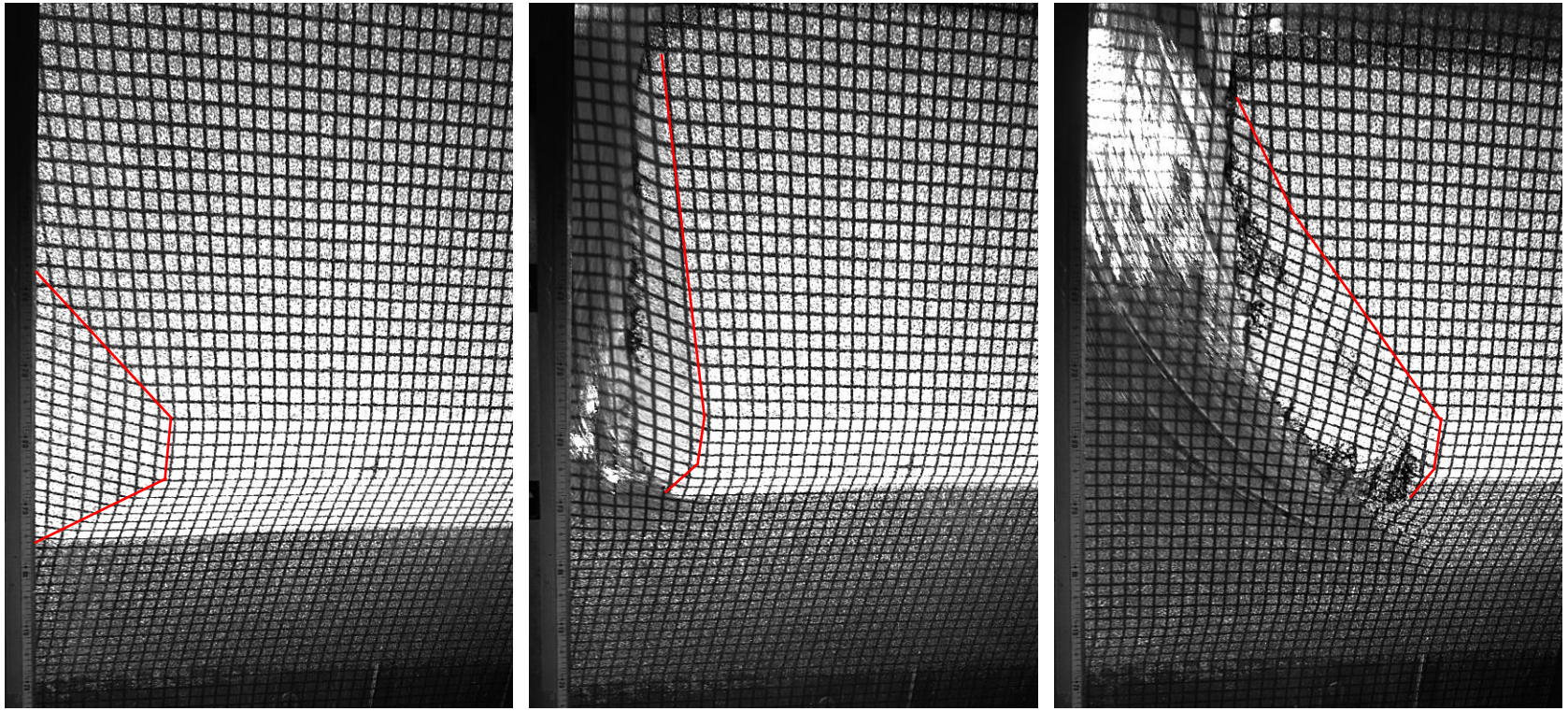


Numerical modeling: representation of surface erosion



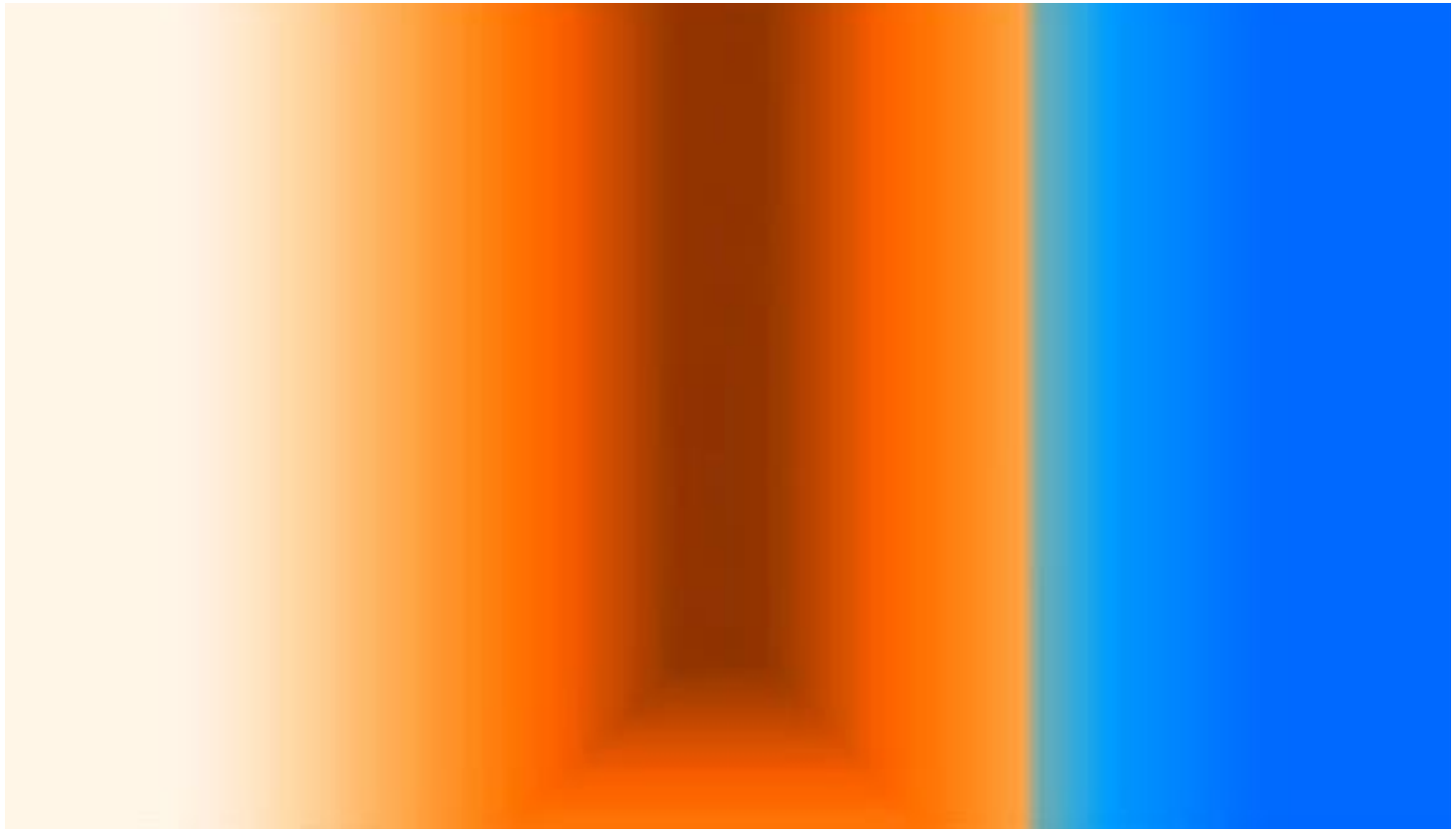
Bed load transport with Meyer-Peter & Müller (1948) transport formula

Numerical modeling: representation of sidewall failures

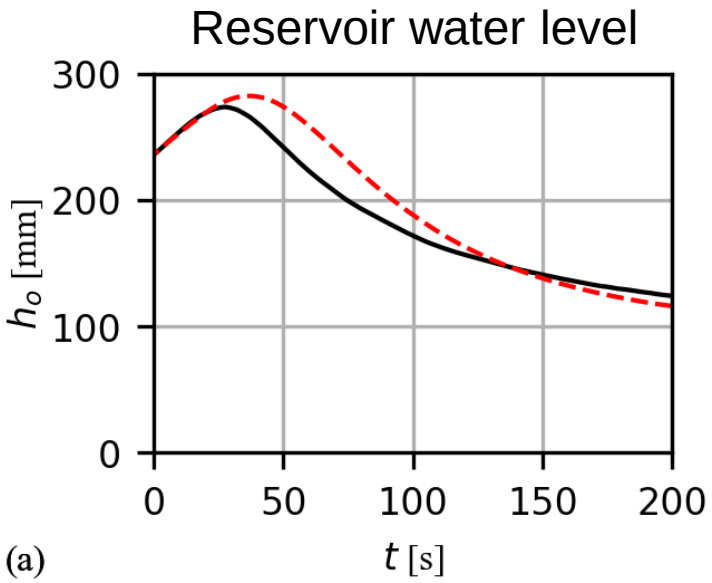


Gravitational transport based on critical failure angles

Numerical modeling: embankment erosion

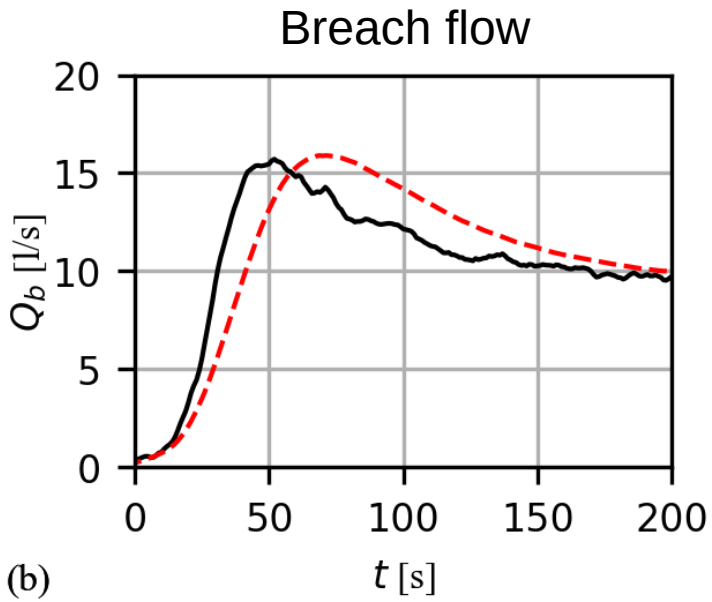


Hydraulic results: laboratory experiments and numerical modeling



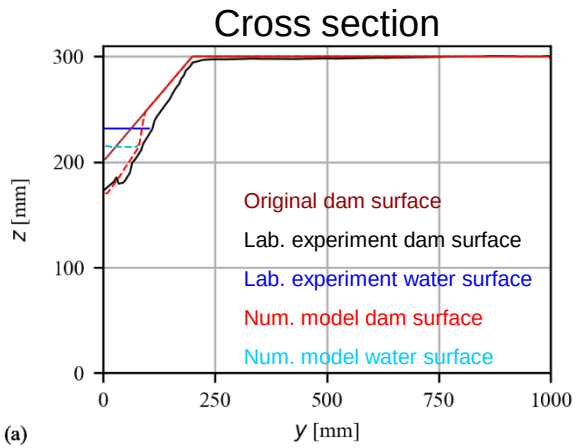
Laboratory experiment

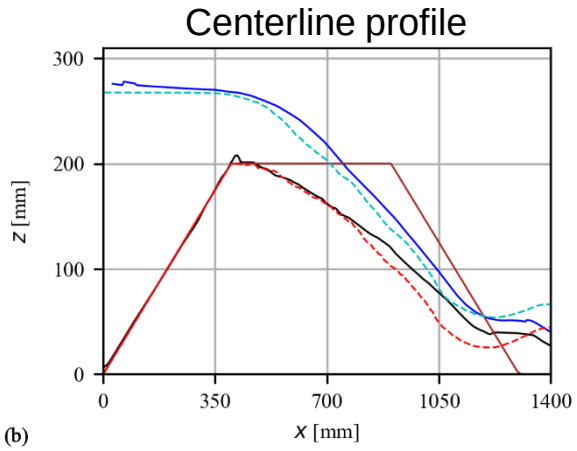
Numerical model



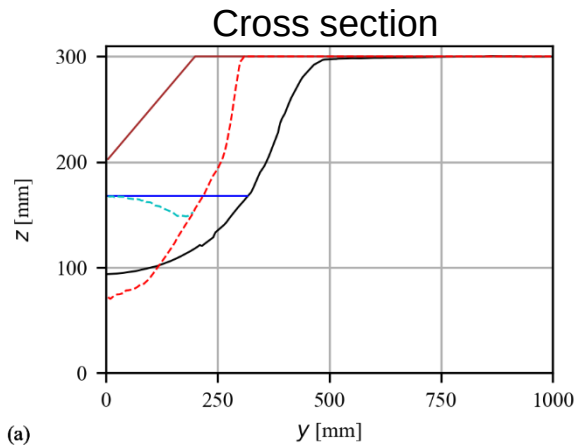
Breach development results: laboratory experiments and numerical modeling

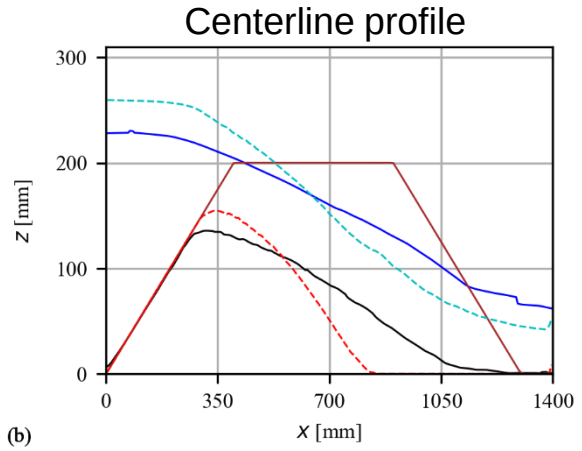
Initial breach formation (t = 20 s)



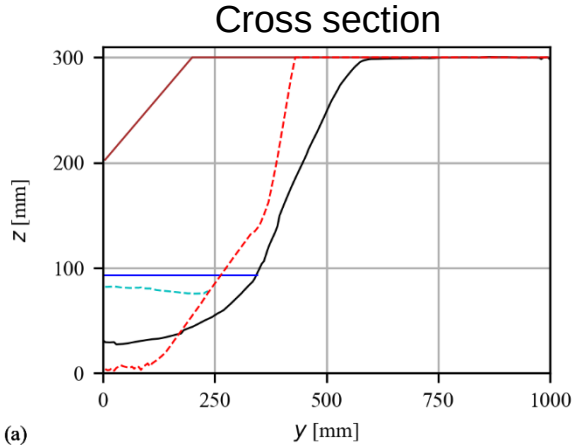


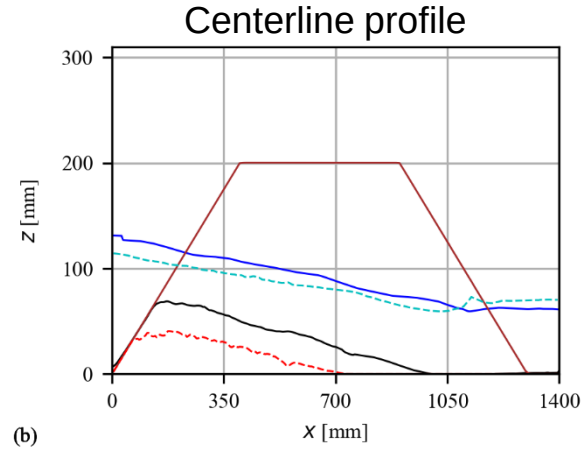
Horizontal expansion by sidewall failures (t = 60 s)





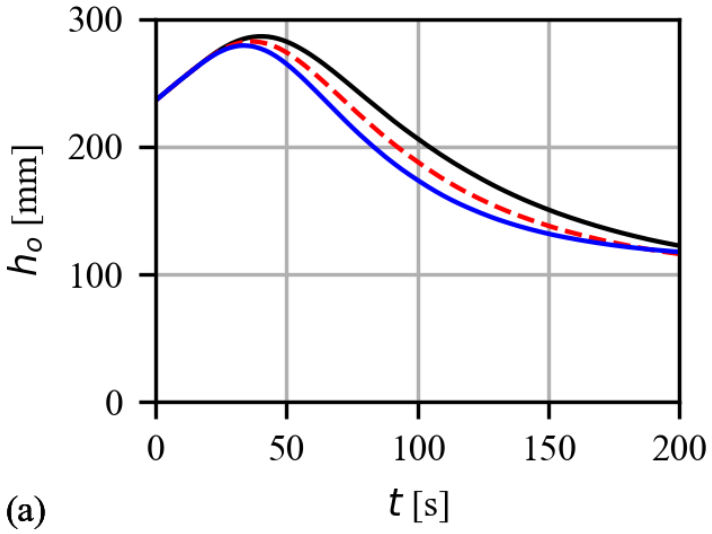
Stabilization (t = 200 s)





Numerical modeling to investigate effects of various parameters on dam breaching

Reservoir water level

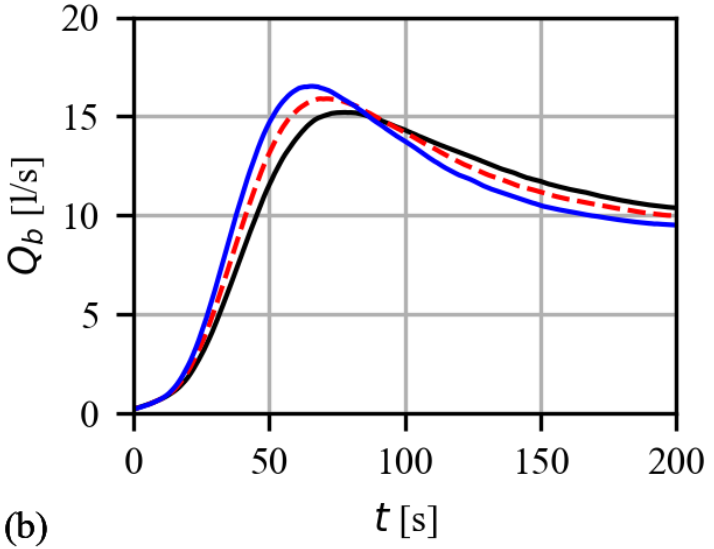


Medium sand

Coarse sand

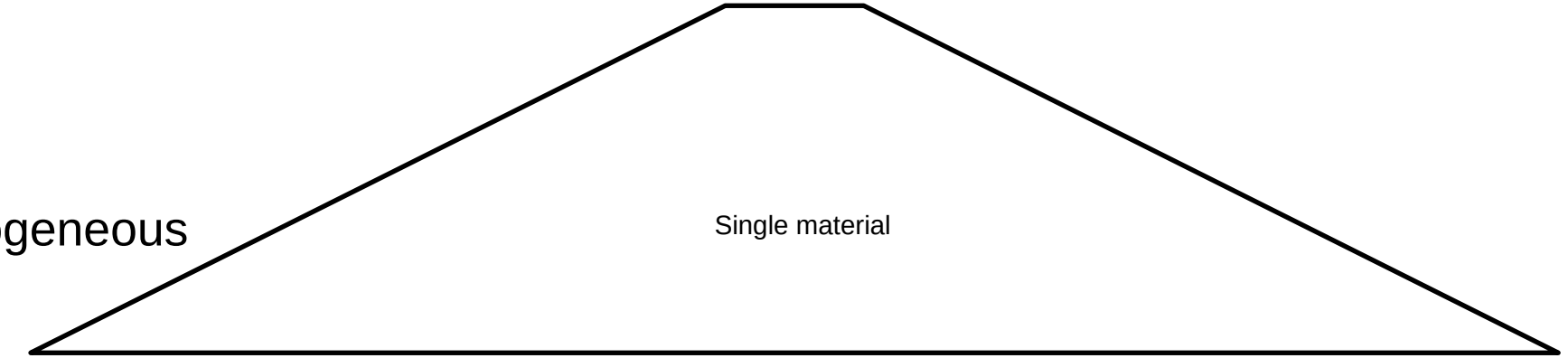
Fine gravel

Breach flow

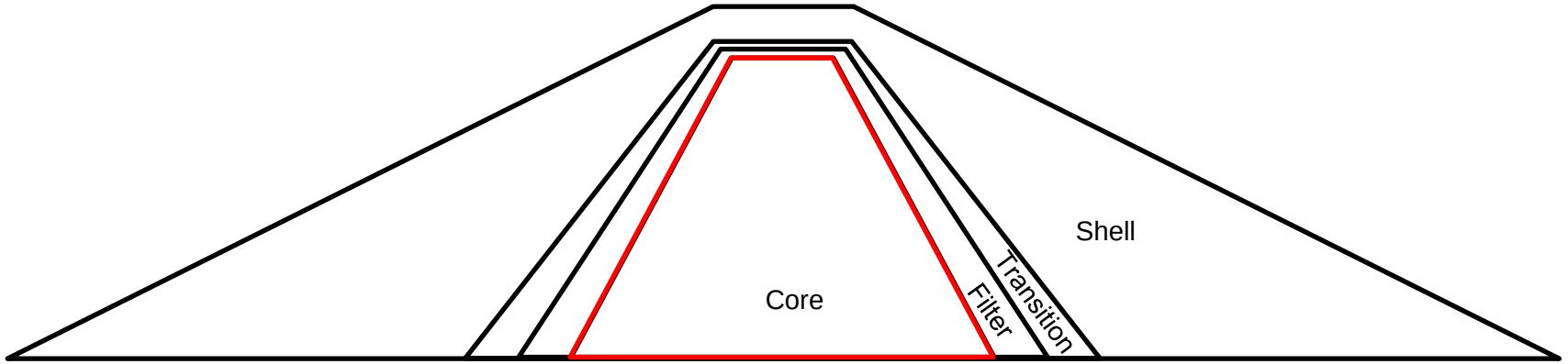


Outlook: Zoned dams

Homogeneous



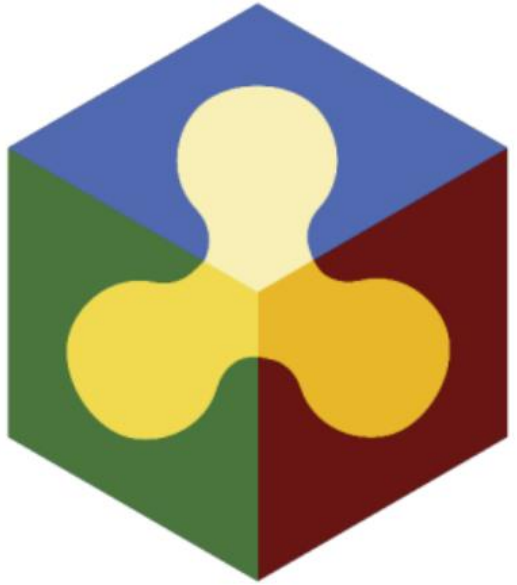
Zoned



Outlook: Implementation

- Enhancement of parameter model BASEbreach

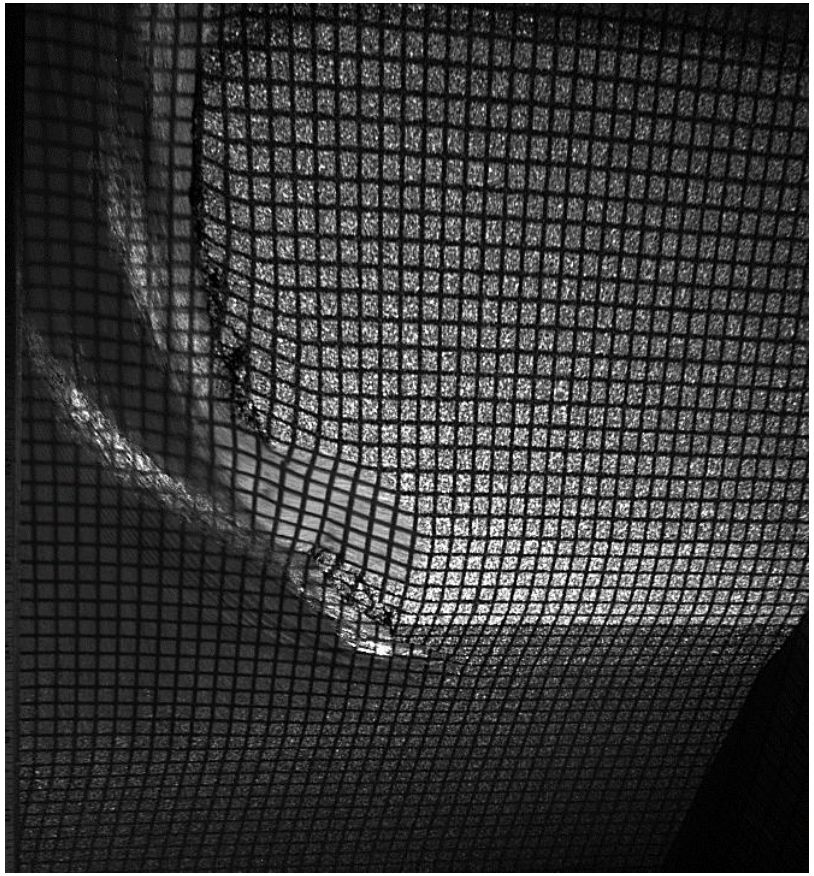
- BASEMENT internal boundary condition: embankment breach parameter model

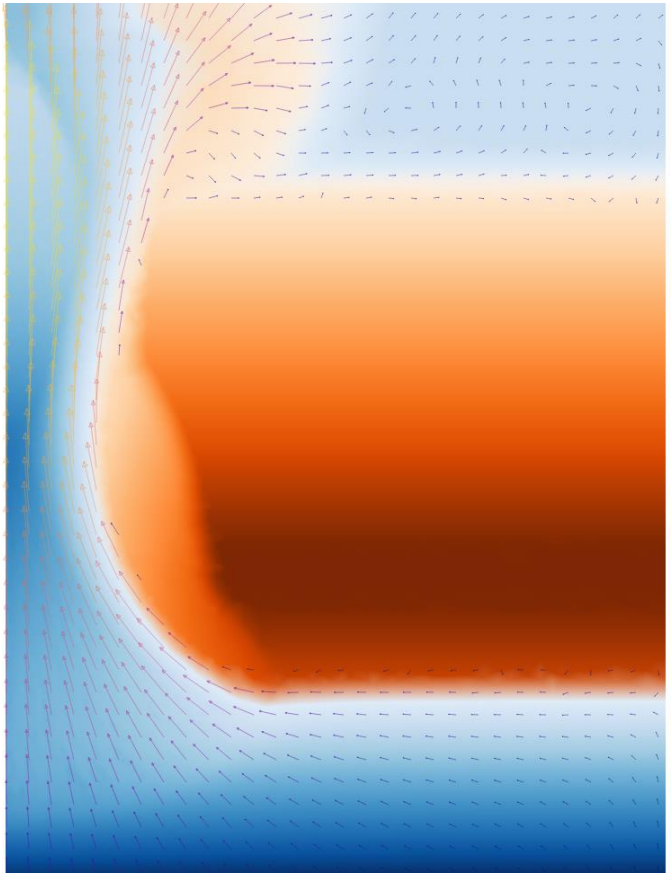


Questions?

Matthew Halso

halso@vaw.baug.ethz.ch





Thank you to the Swiss National Science Foundation for support!