Esther Rosenbrand

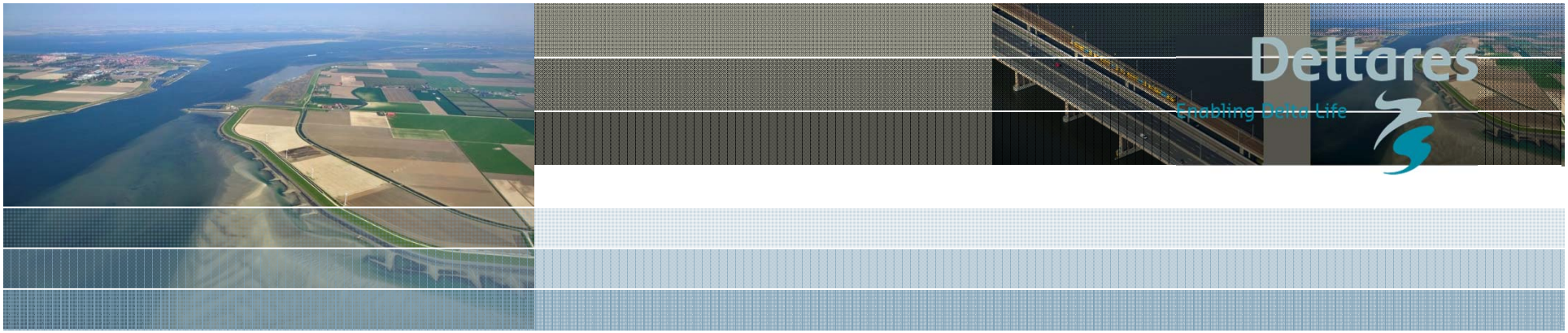
Esther Rosenbrand is a researcher and geotechnical advisor at Deltares, an independent institute for applied research in the field of water subsurface and infrastructure in the Netherlands. For the past two years, she has done research on a novel remediation measure against backward erosion piping, which is being developed in a multi-scale experimental program at Deltares.

Backward Erosion Piping: a multi-scale investigation of a novel remediation technique

In the field of flood defenses, Deltares develops knowledge for new assessment methods and technologies for reinforcing dikes. Backward erosion piping (BEP) poses a significant threat to the Dutch levees. Therefore, the coarse sand barrier (CSB) is being developed as a cost-effective nature-based measure to prevent a pipe from leading to embankment failure.

The concept of the CSB is based on a physical understanding of the mechanisms that cause the pipe to progress upstream below an embankment. The loosening of grains at the tip of the pipe due to the hydraulic forces, is the key factor to the effectiveness of the barrier. The progression of a pipe in the presence of a CSB was investigated by means of laboratory experiments at different scales (aquifer depths of 0.10 m and 0.40 m) to investigate effects of geometry, scale and different material combinations. Subsequently two larger scale experiments (aquifer depth 3.0 m) were conducted in the Delta Flume test facility at Deltares to develop further confidence in the measure.

The combination of laboratory experiments and numerical modelling was used in order to better understand the process, and to derive a strength criterion, which allows for design of reinforcement of embankments with the measure. Subsequent steps will involve tests by constructors to investigate the feasibility of placing the measure in the field, and a pilot test at a real embankment in the Netherlands.

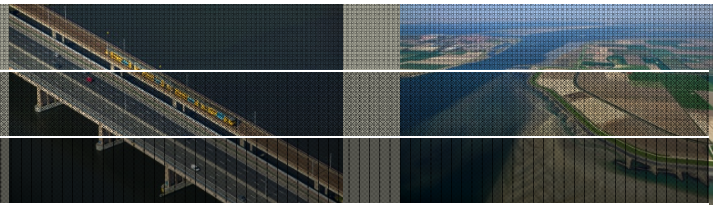


Backward Erosion Piping:
a multi-scale investigation of a novel remediation technique the coarse sand barrier

Esther Rosenbrand, Vera van Beek

Deltares

Outline



Backward erosion piping

Concept behind the coarse sand barrier

Experimental program

Results

Outlook

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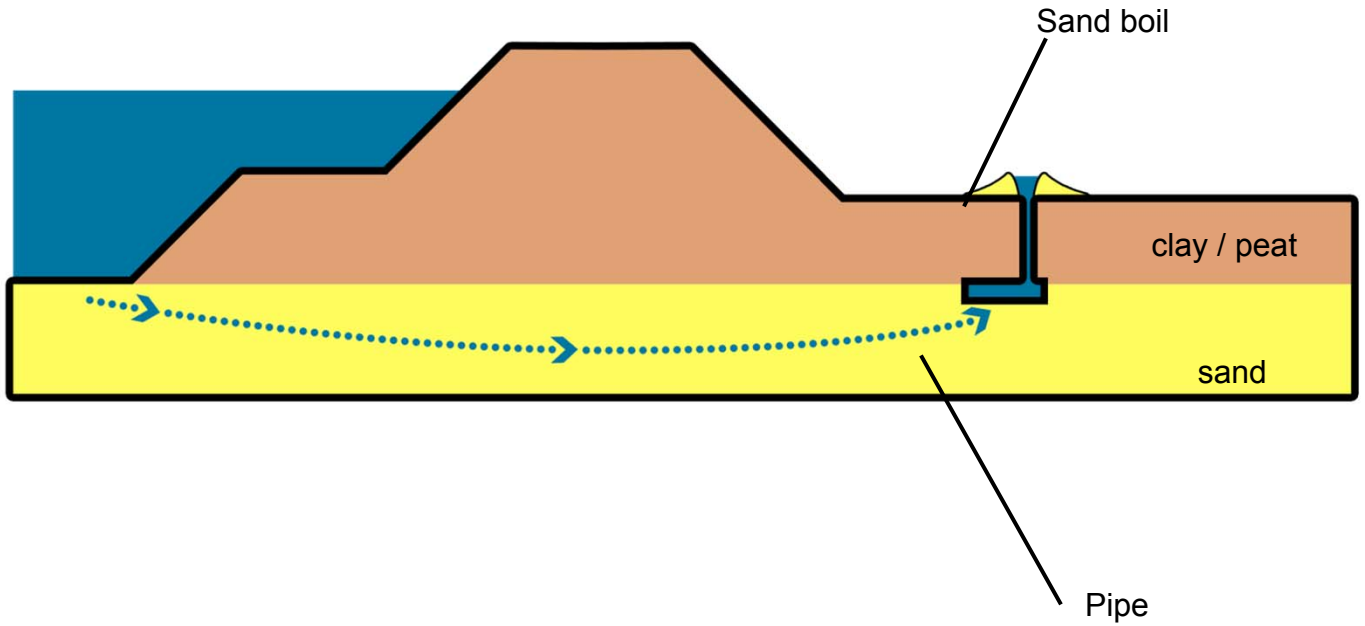
Backward erosion piping



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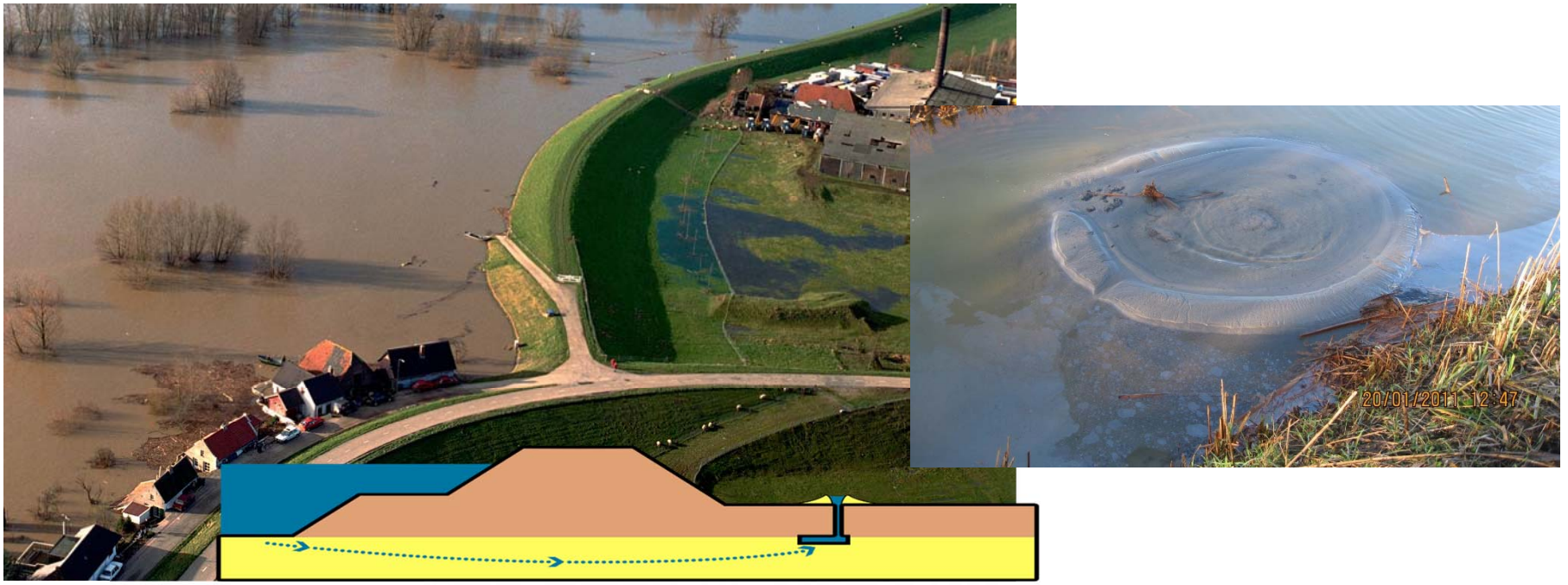
Piping threat in the Netherlands



Photos: Beeldbank Rijkswaterstaat

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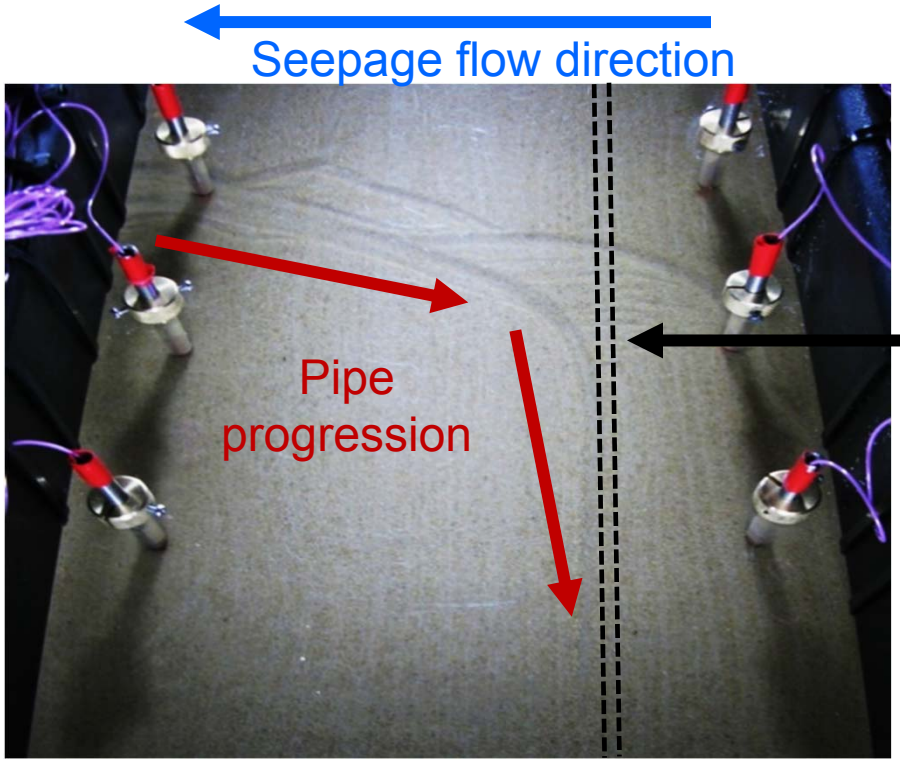
Nature based solution: Coarse sand barrier



Layering results in higher critical head drop

Modified after Van Beek, 2015

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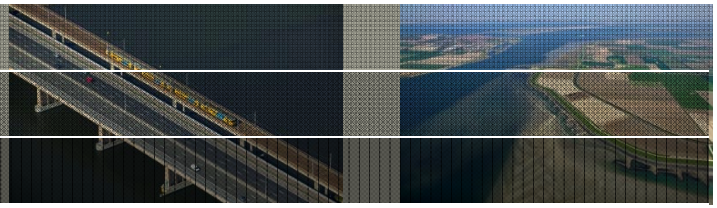
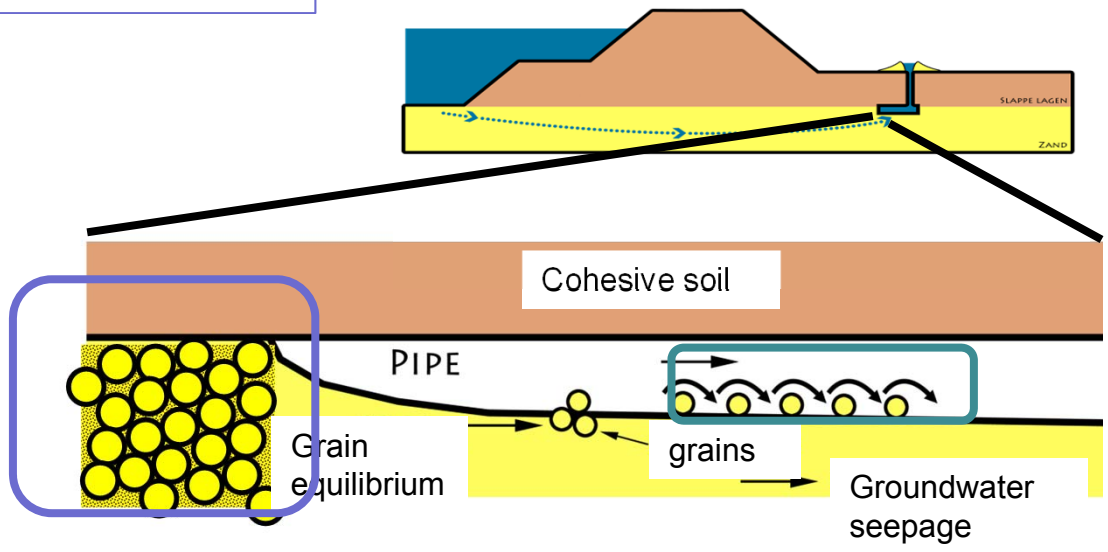
Pipe progression



Loosening of grains at pipe tip

Transport of grains inside pipe



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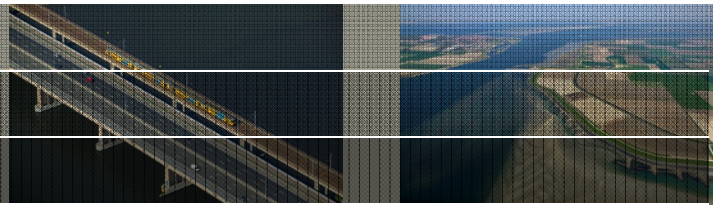
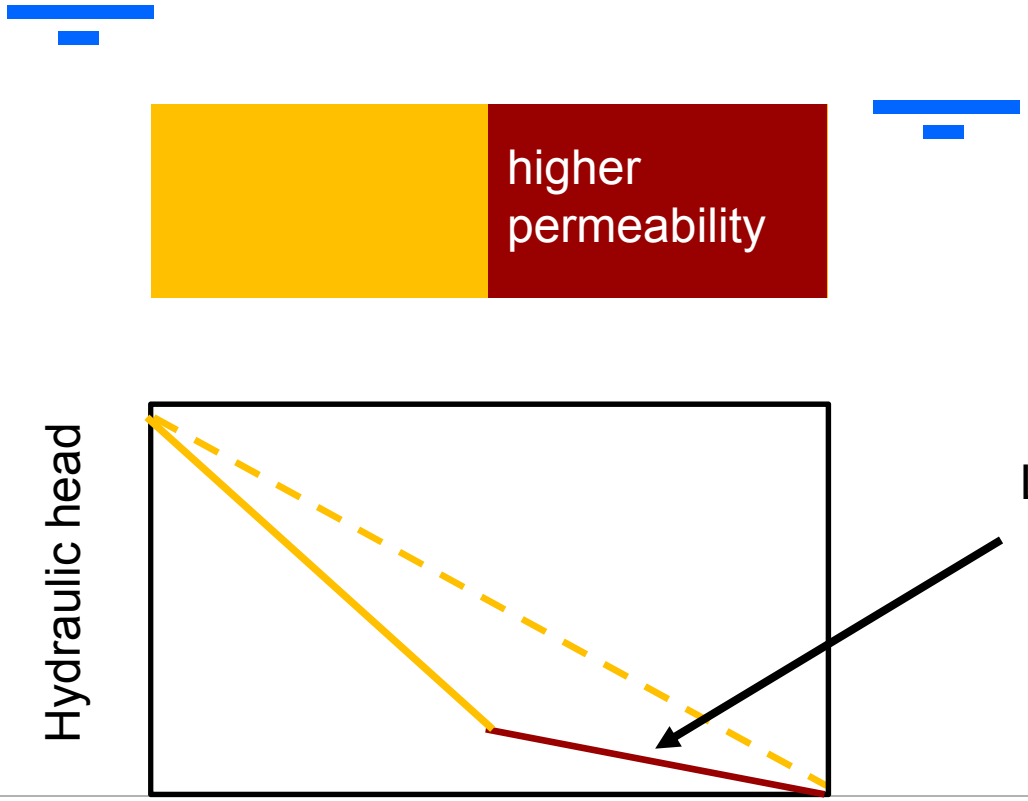
CSB: lower load in barrier





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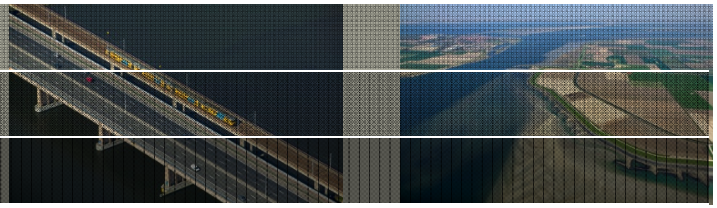
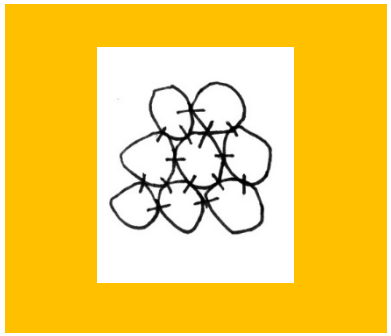
CSB: higher resistance

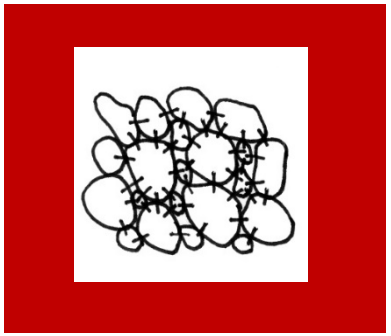


Resistance: particle contacts

Uniform



Broadly sorted



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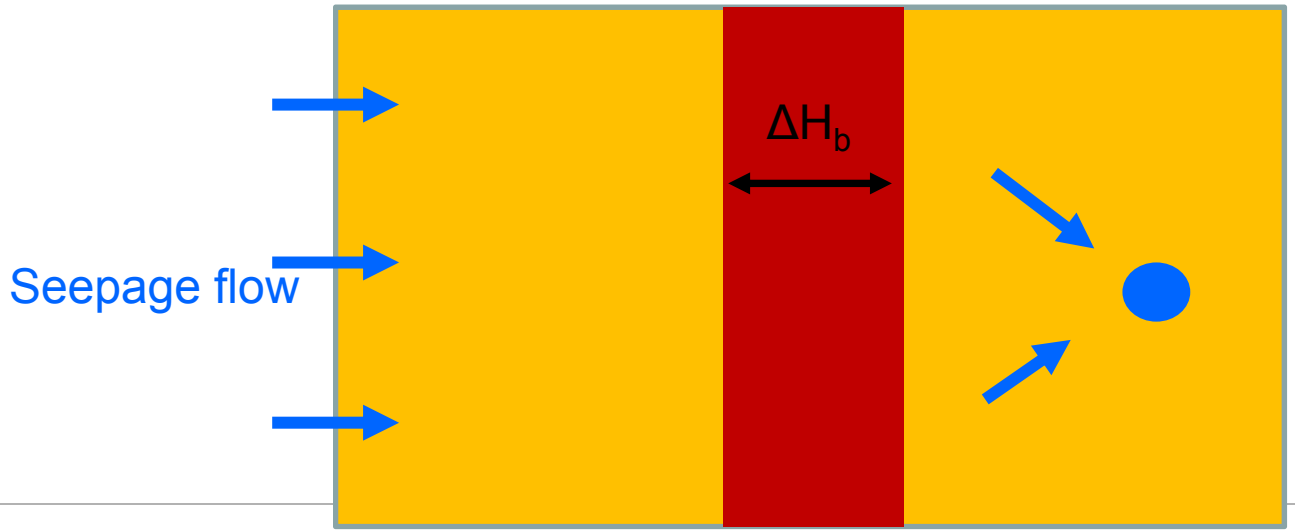
Experimental programme: objective

Design a barrier material for the pilot site and quantify barrier strength.

Hypothesis:
strength = critical gradient for pipe progression = material property



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3 scales of experiments

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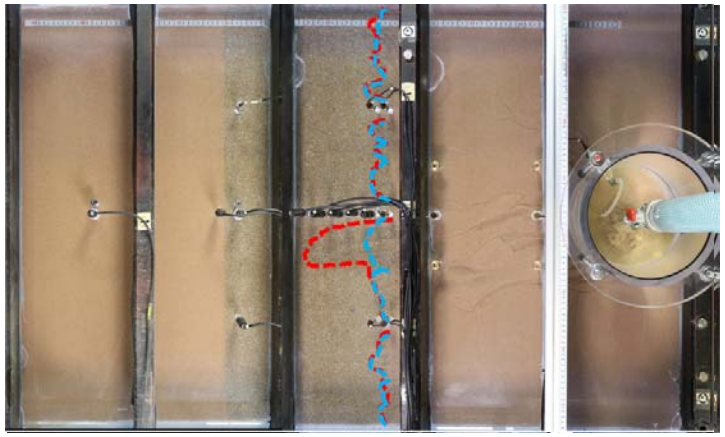
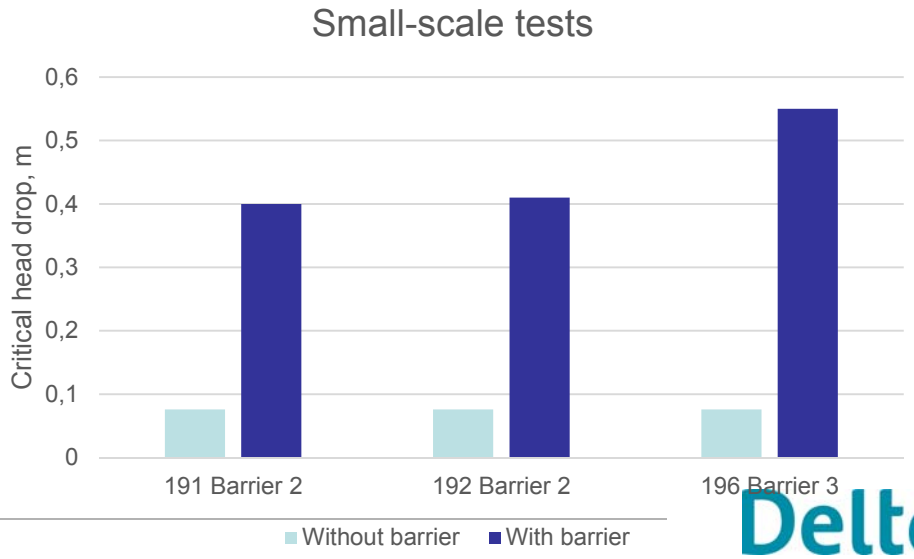
Results

-Pipe first progresses parallel to the barrier
-Crumbling of barrier
-Pipe growth in steps
-Critical step: defined based on measured pore pressures & observations
-Head drop at critical step is significantly higher than in reference test without a barrier for small- and medium- scale tests





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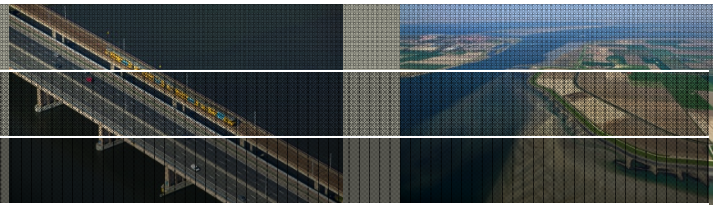
Results & Outlook



Outlook

- Predict strength for pilot
- Design guideline
- Construction of barrier at pilot site

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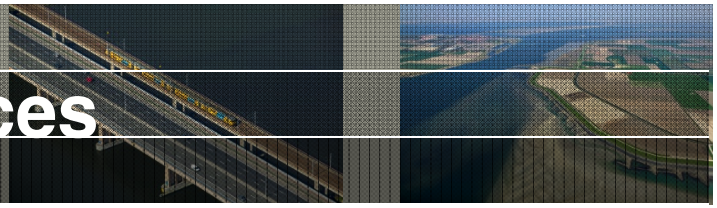
Acknowledgement & References



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Waterboard Rivierenland

References

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Van Beek, V., 2015, Backward Erosion Piping Initiation and Progression, PhD Thesis, Delft University of Technology.