



## **Slotconferentie Zeeweringen**

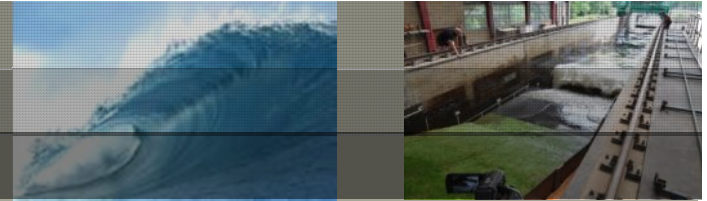
### **Havendammen**

Mark Klein Breteler  
Deltares

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# Overzicht van presentatie

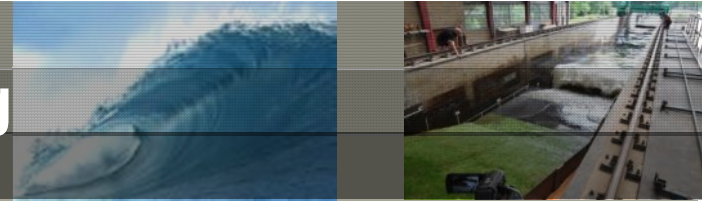


1. Inleiding
2. Onderzoeksaanpak
3. Kleinschalige proeven en numerieke berekingen
4. Verificatie in Deltagoot





# Havendammen voor de waterkering

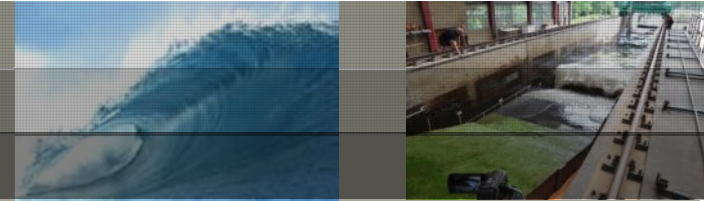


dijk

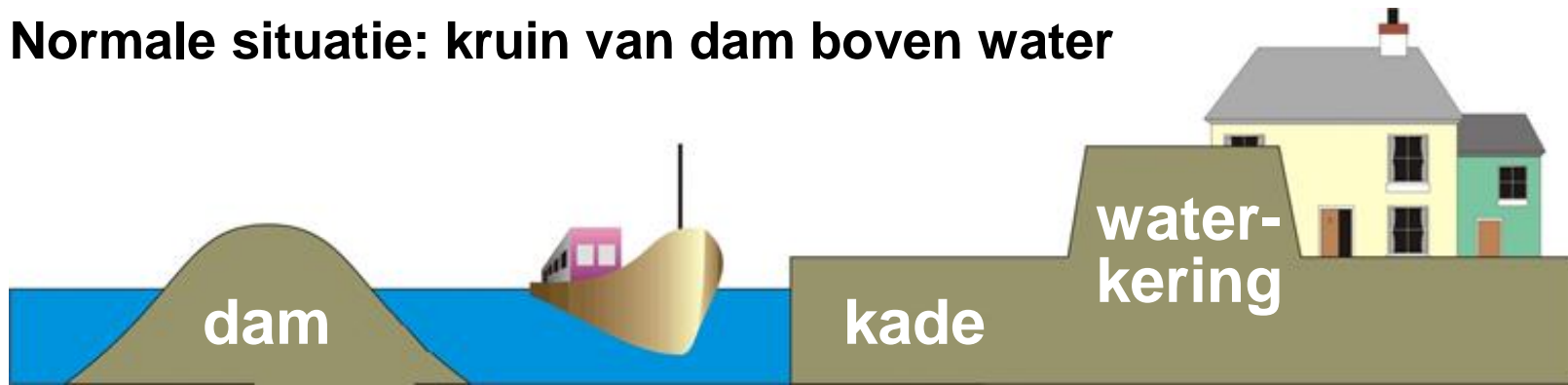
Harlingen

Deltares

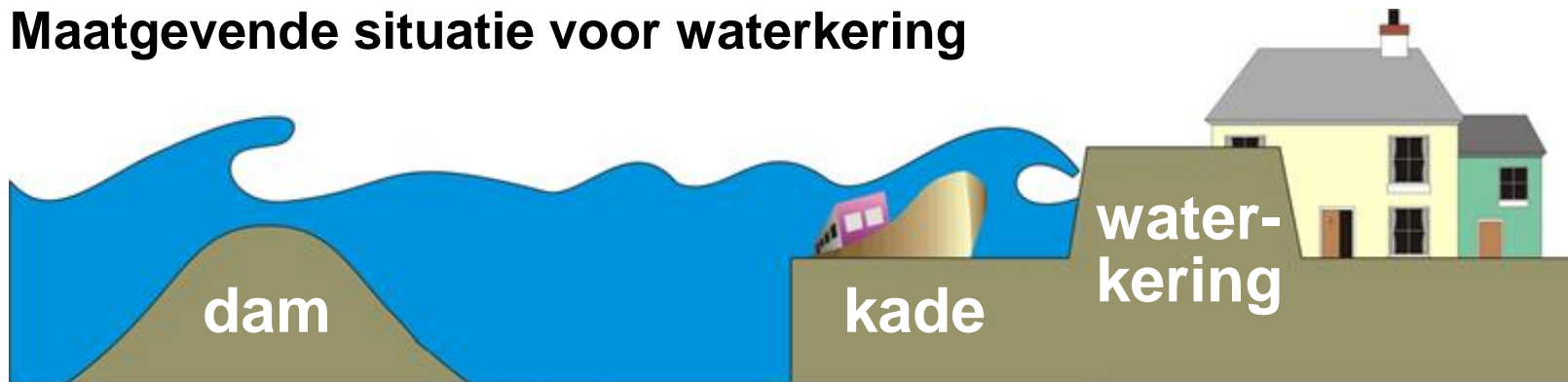
# Havendam reduceert golfaanval



**Normale situatie: kruin van dam boven water**



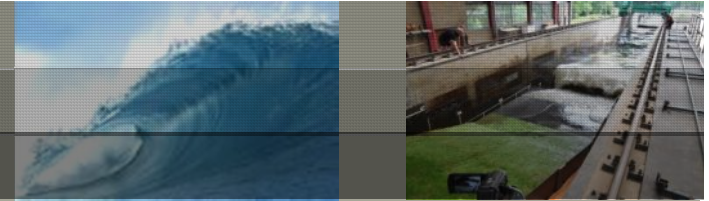
**Maatgevende situatie voor waterkering**



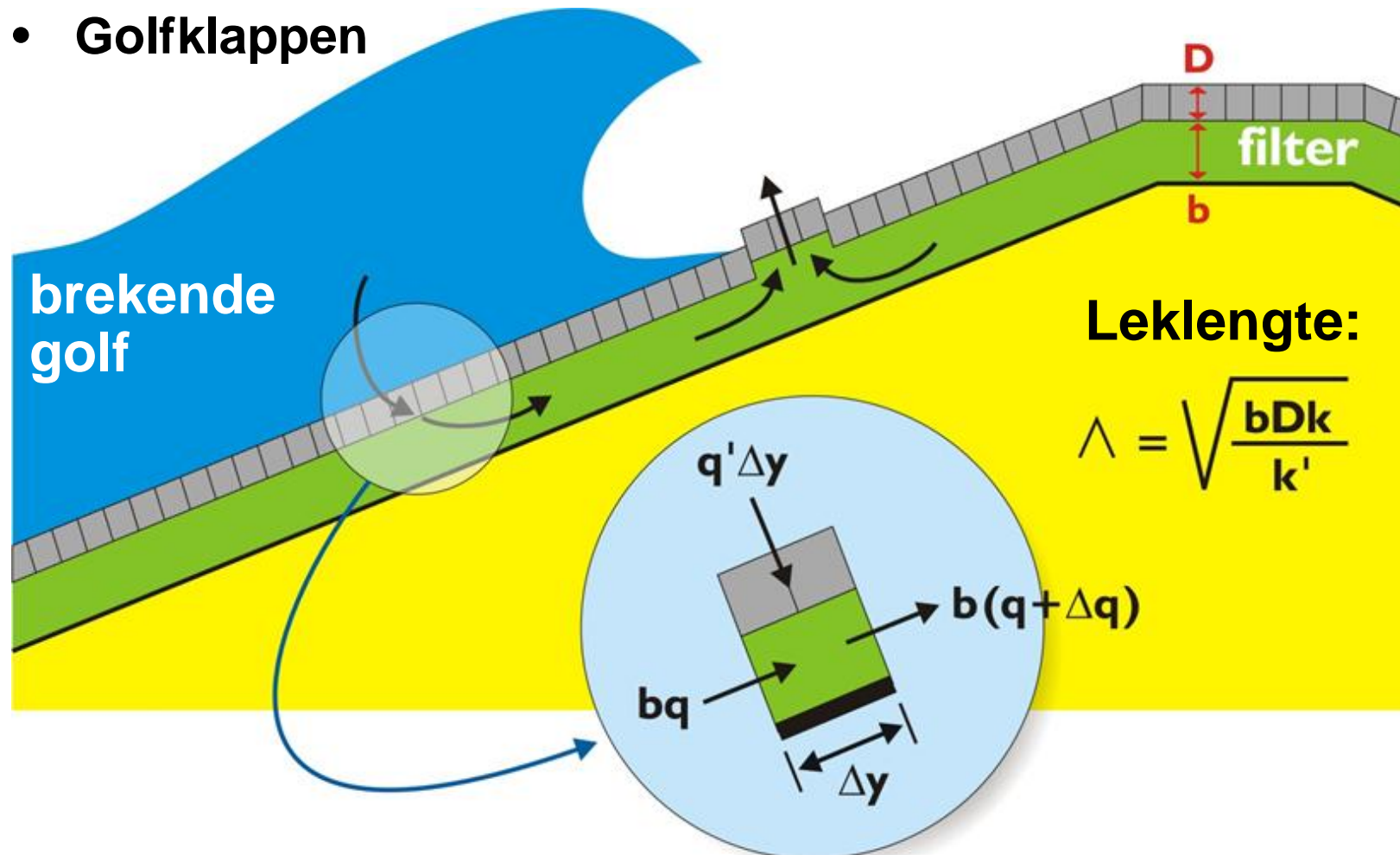
**Deltares**

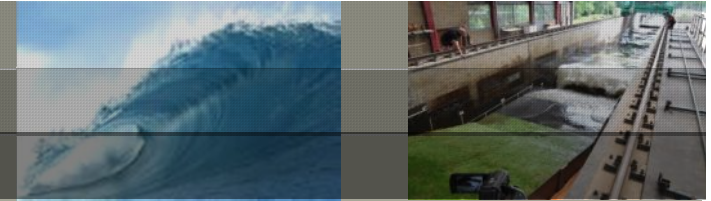


# Schademechanisme



- **Golfneerloop met stijghoogtefront**
- **Golfklappen**





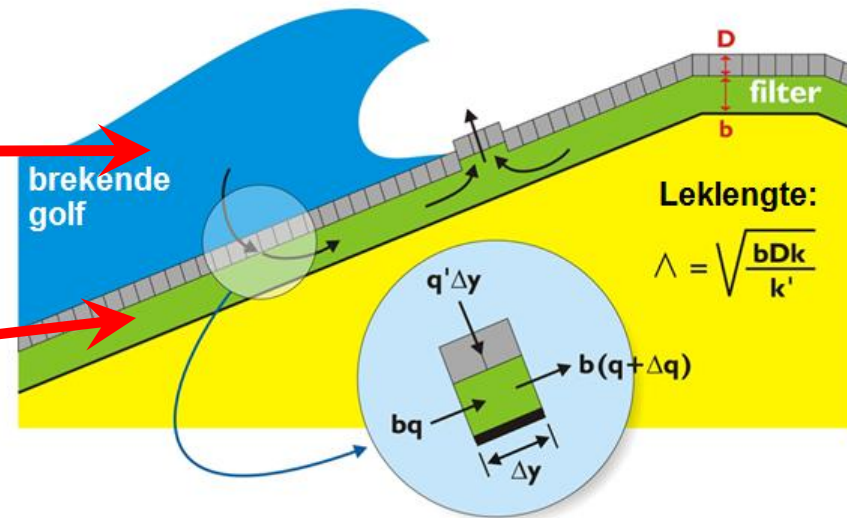
## Conflicterende schaalregels:

Golven:

Froude schaling:  $Fr = u/\sqrt{gL}$

Stroming in the filter:

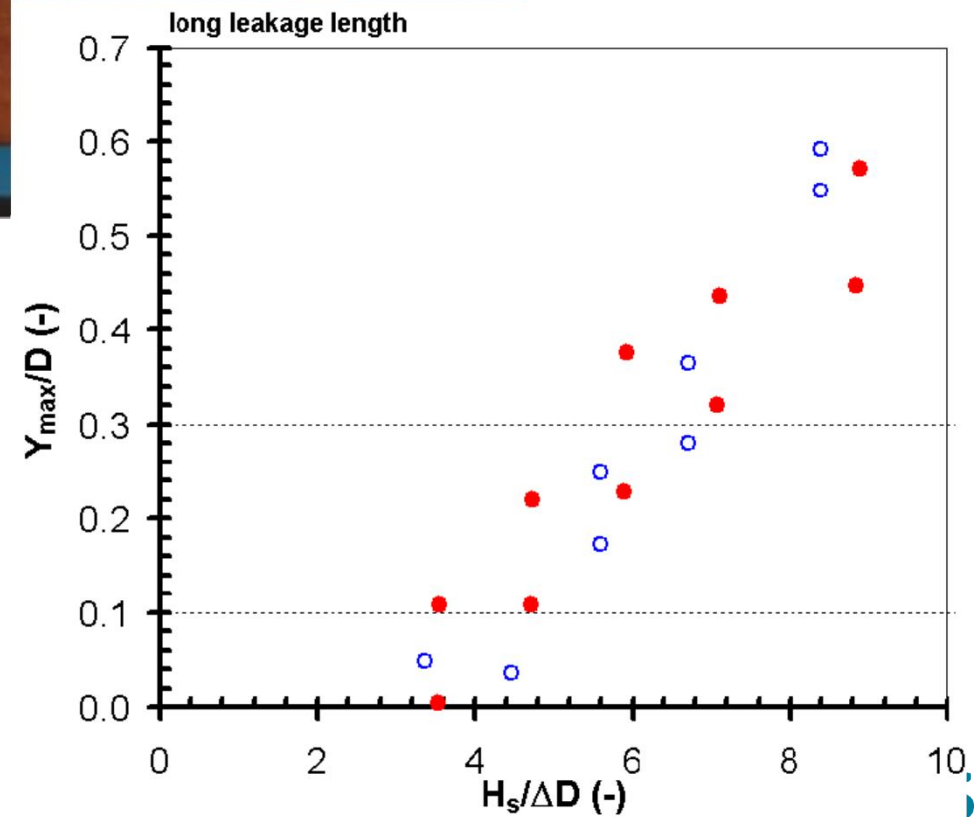
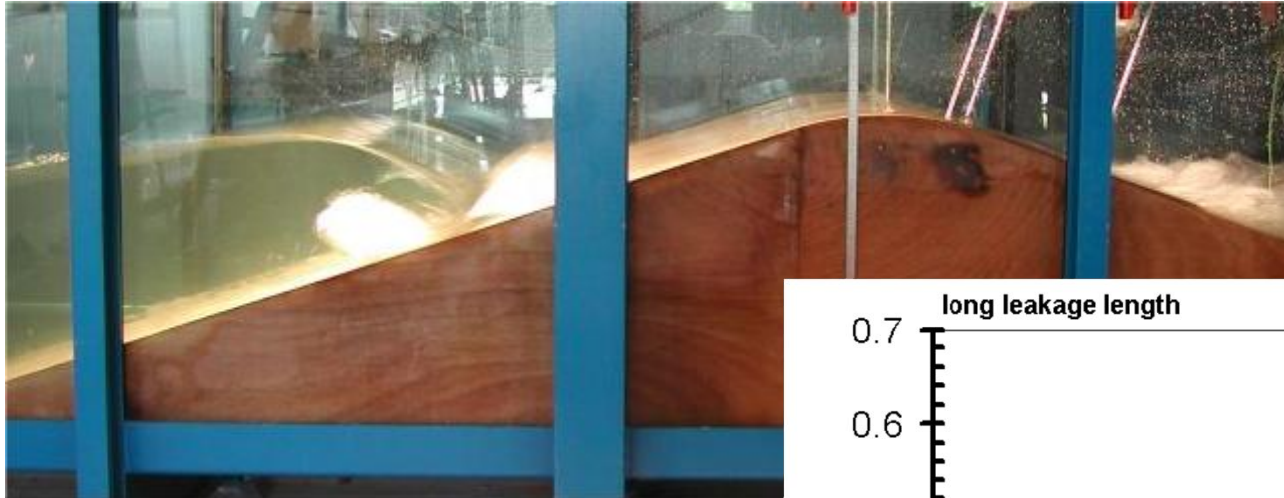
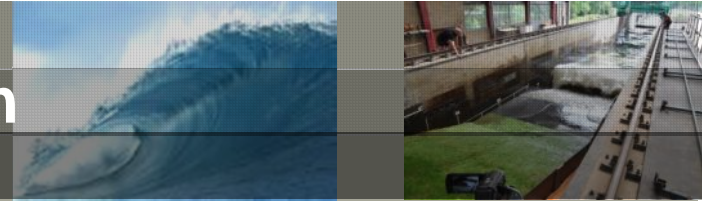
Reynolds schaling:  $Re = uL/\nu$



## Aanpak:

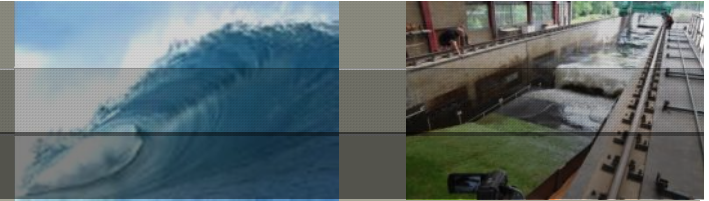
- Kleinschalige tests: drukmetingen op constructie
- Numerieke berekeningen (Zsteen):
  - Stijghoogteverschil over toplaag
  - Stabiliteit van steenzetting
- Verificatie: Deltagootproeven

# Drukmetingen als input voor Zsteen





# Verificatie in Deltagoot



## Deltagoot in Noordoostpolder:

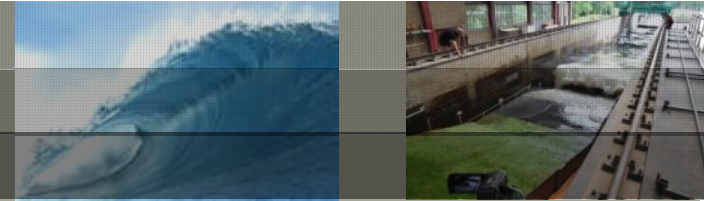
- 235 m lang
- 5 m breed
- 7 m diep
- $H_{\text{smax}} = 1.7 \text{ m}$



**Deltares**

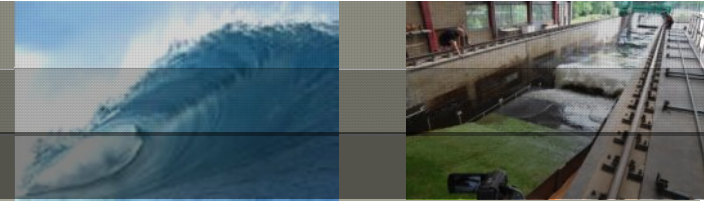


# Deltagootproeven

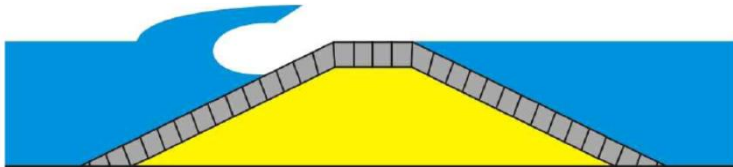


**Deltares**

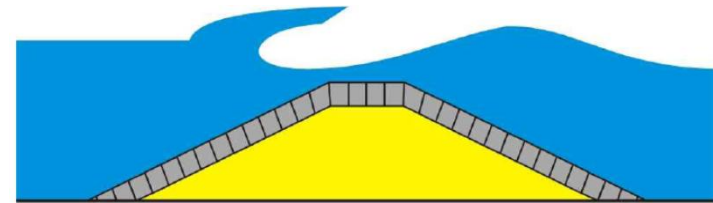
# Deltagootproeven



$h_c = 0$ : schade bij  $H_s = 1,67$  m



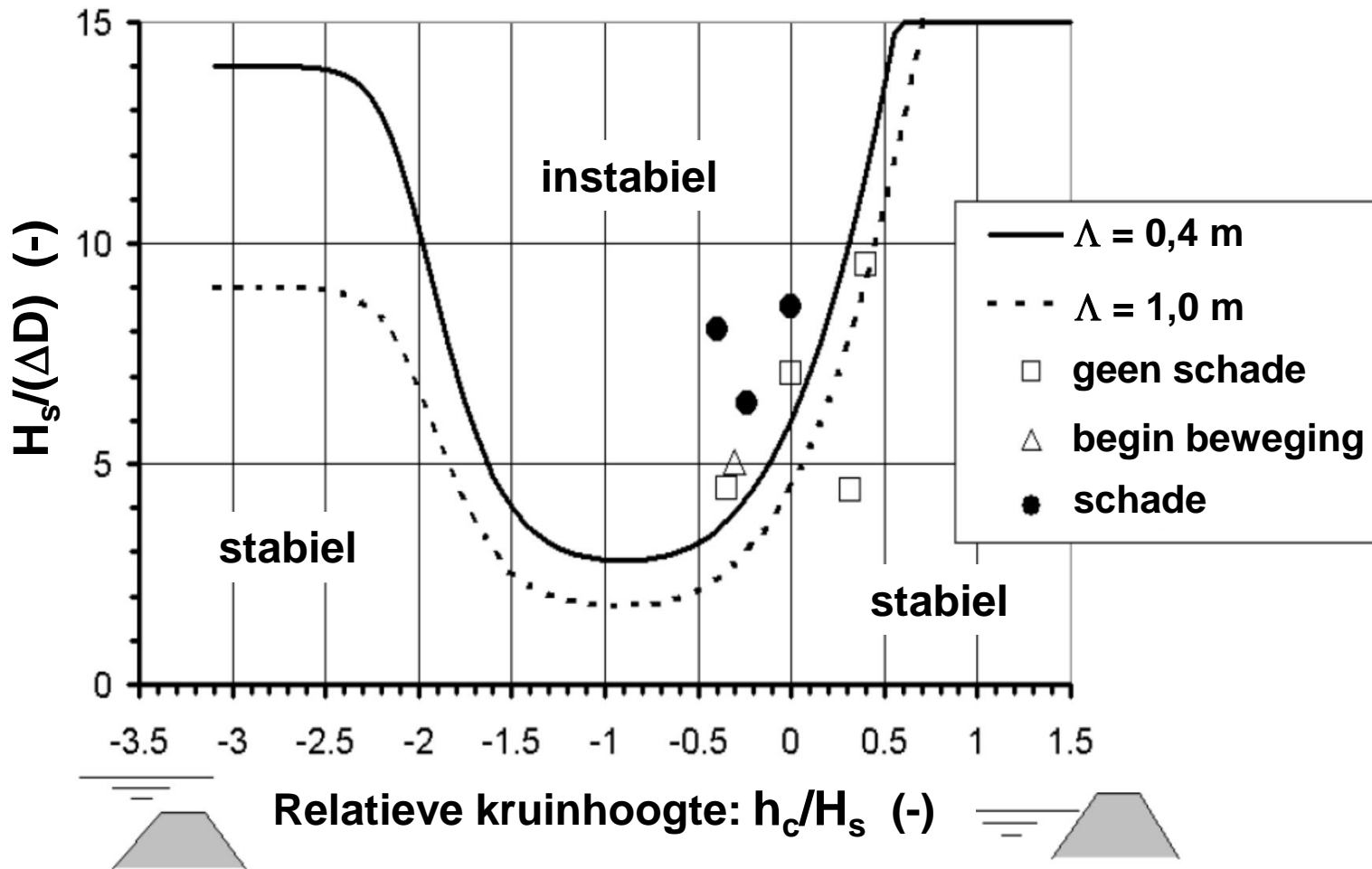
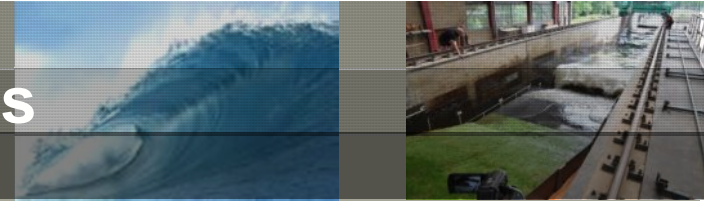
$h_c = -0,4H_s$ :  
Schade bij  $H_s = 1,15$  m



**Deltares**



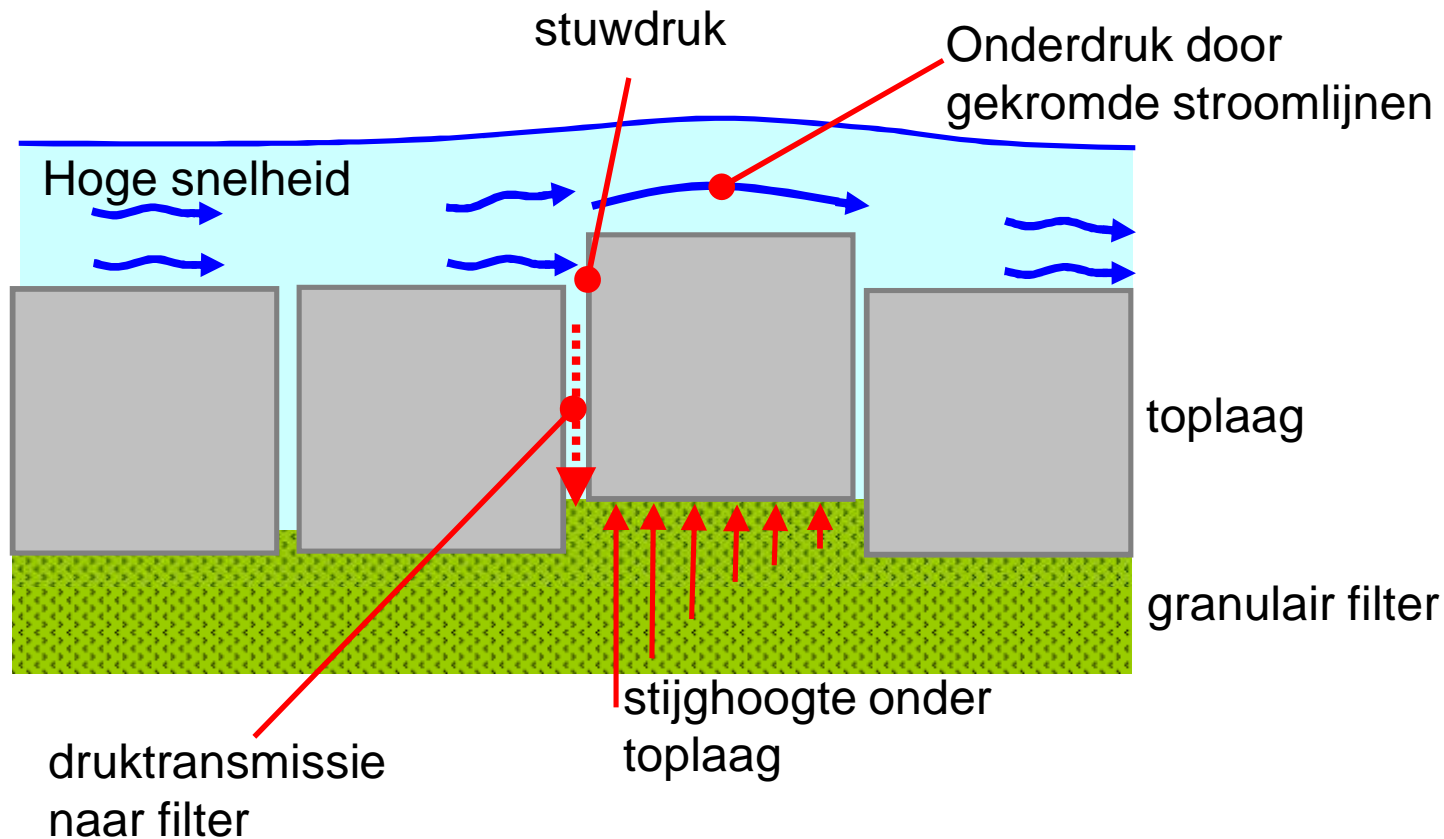
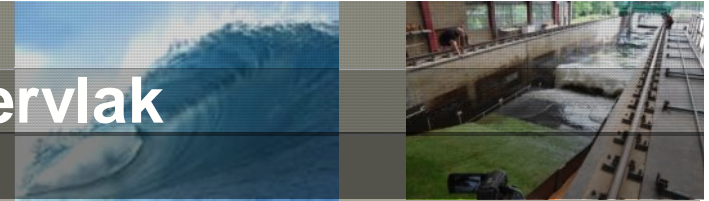
# Resultaat, opgenomen in Steentoets



$h_c$  = kruinhoogte t.o.v. toetspeil (m)



## Extra aspect: oneffenheden in oppervlak



Ook dit extra aspect is opgenomen in **Steentoets**

**Deltares**