Deltares
Enabling Delta Life

Stability comparison of 9 modern placed block revetment types for slope protections

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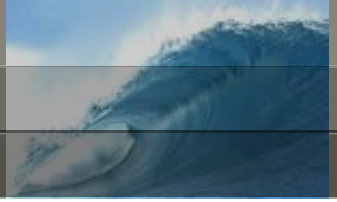
Block revetments



$H_s < 4$ m

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Overview

- Damage mechanism and hydraulic load
- Objective of project
- Tested types of block revetments
- Delta Flume experiments
- Conclusions

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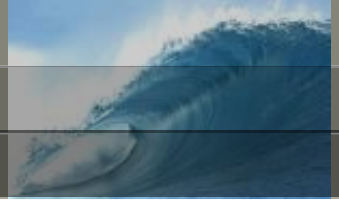
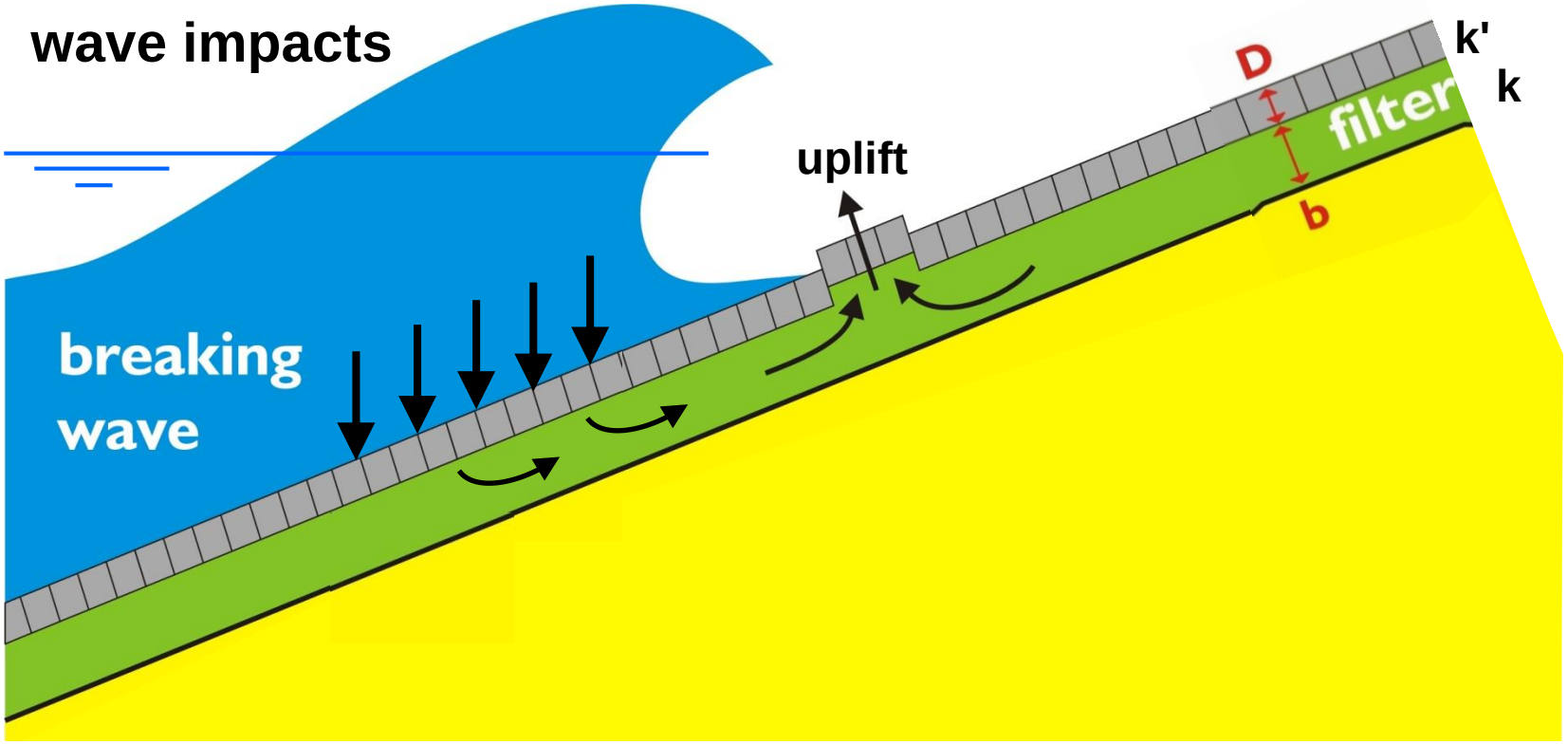
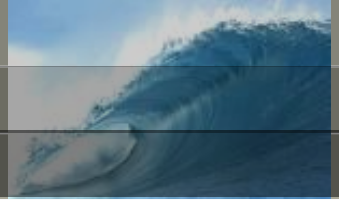
Damage mechanism



- **pressure front**
- **wave impacts**



Damage mechanism



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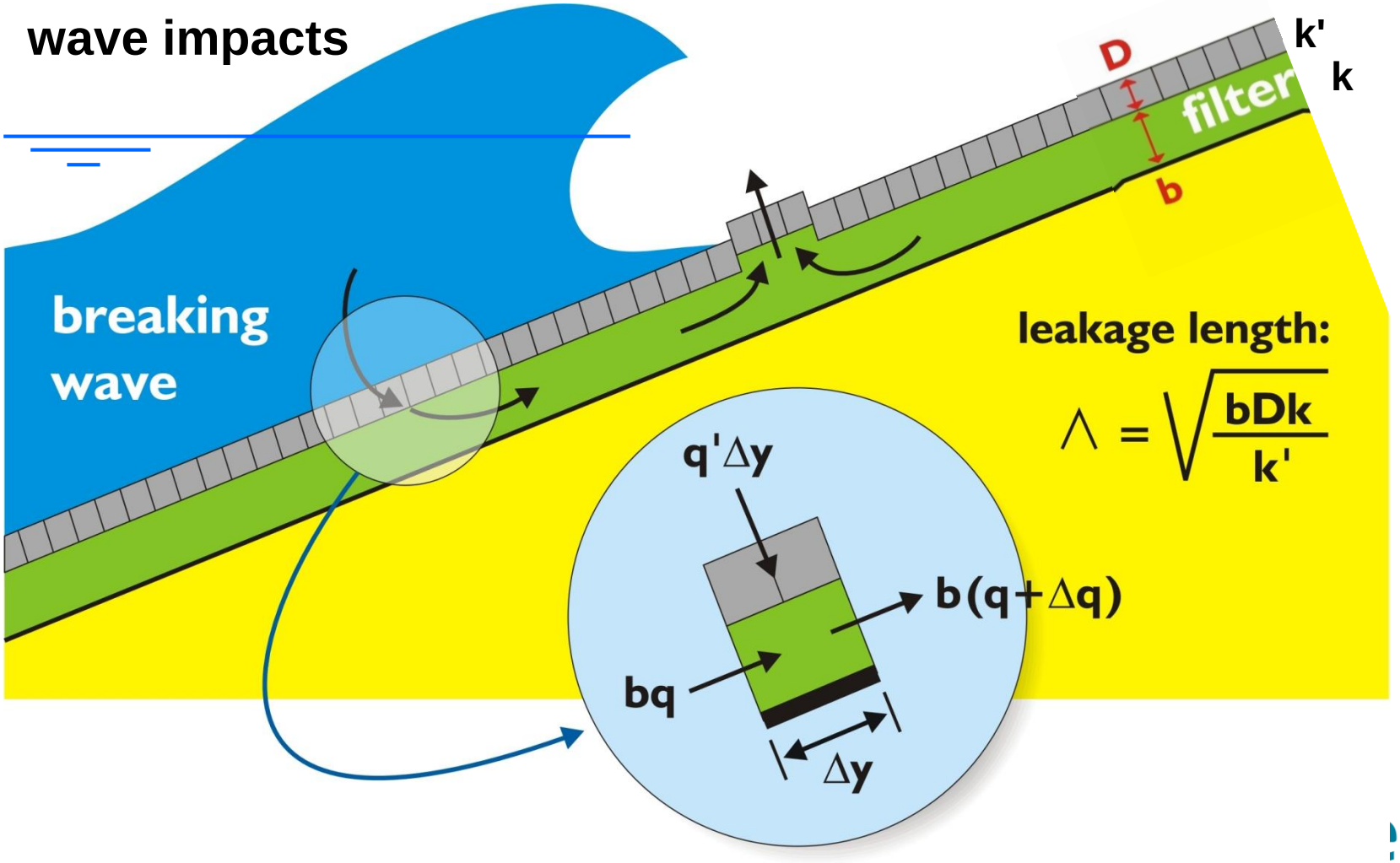
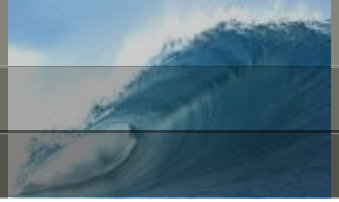


Aspects of stability



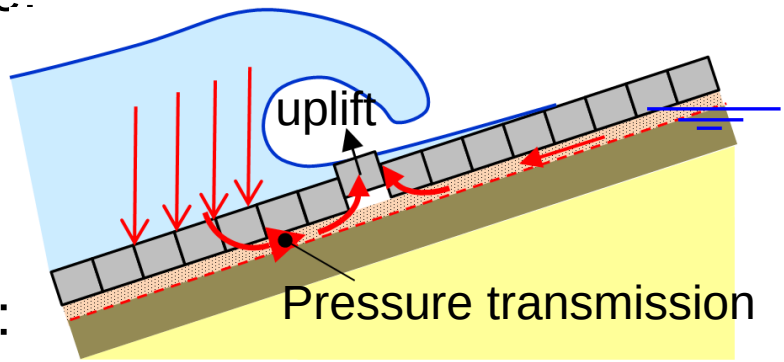
- **Low leakage length:** Sufficient permeability of the cover layer (relative to filter layer) to minimise uplift pressure
- **Weight of the blocks**
- **Interaction of the blocks**

Calculation method

Steentoets:

- Characteristic pressure on the slope:
  - During maximum run-down (pressure front)
  - During wave impact
- Empirical formula's for permeability:
  - Cover layer
  - Granular filter layer
- Calculation of uplift pressure (leakage length)
- Stability:

  uplift pressure <> block weight & block interaction



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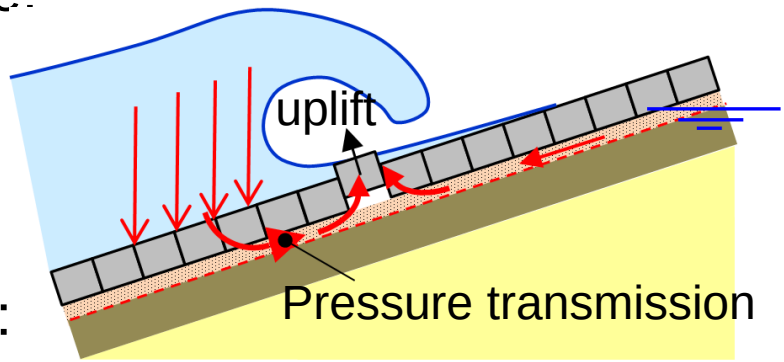

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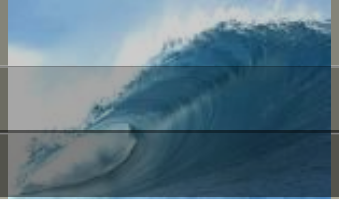
Objective of present project



- Delta Flume tests to find the $H_{s,max}$ at damage: $H_{s,max\ flume}$
- Calculate $H_{s,max}$ at damage with minimum block interaction: $H_{s,max\ calc}$

- Derive **correction factor f on block thickness** to achieve:

$$H_{s,max\ flume} = \gamma H_{s,max\ calc}$$ (with γ for safety margin)

f is different for each type of block revetment.

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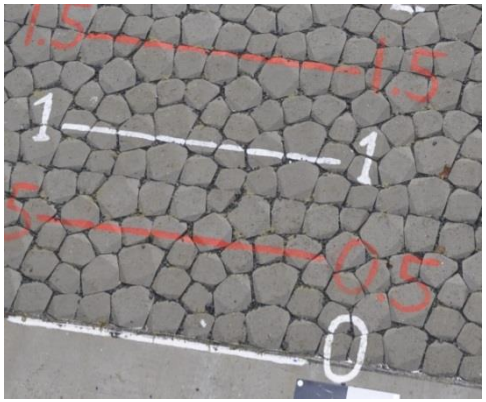
Tested block revetments

Basalton and Basalton+ (manufacturer: Holcim)



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Tested block revetments

Hillblock (manufacturer: Hill)

Hillblock-slim

Hillblock-basis

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Tested block revetments

RONAton and RONAtaille (manufacturer: Altena)

RONAtaille:

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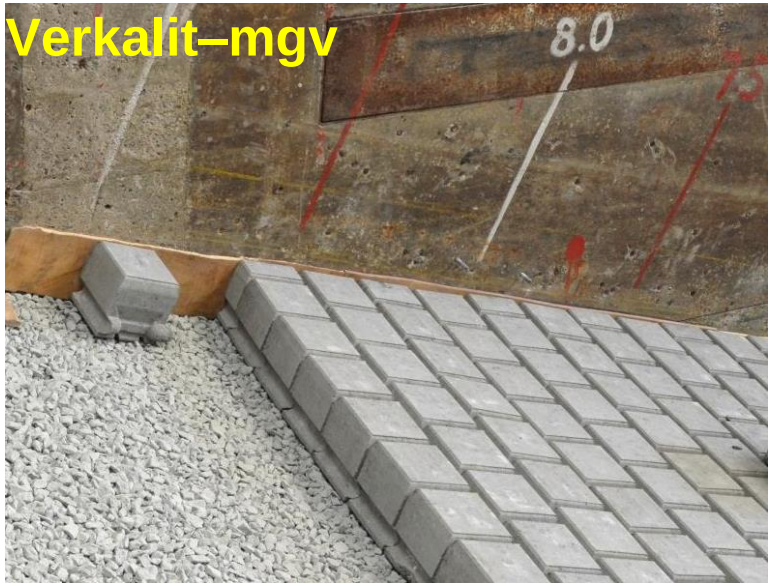
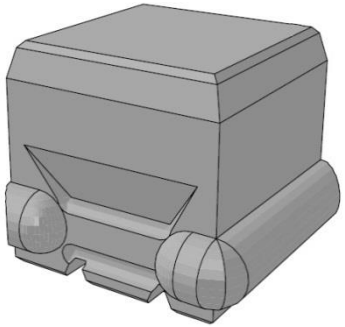
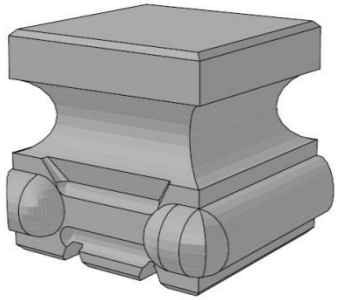
Tested block revetments

Verkalit–mgv and –GOR (manufacturer: LBN/Berding)







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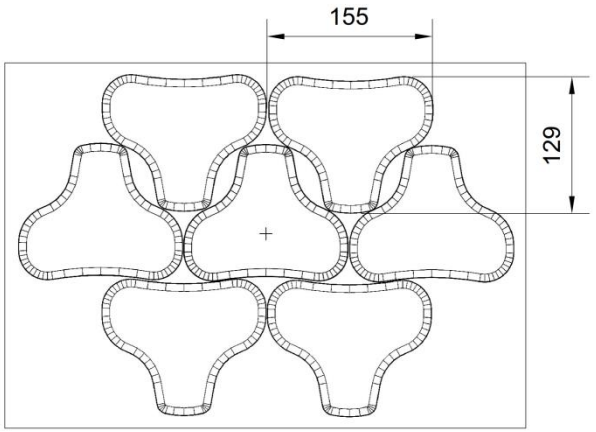
Tested block revetments

C-Star (manufacturer: LBN/Berding)



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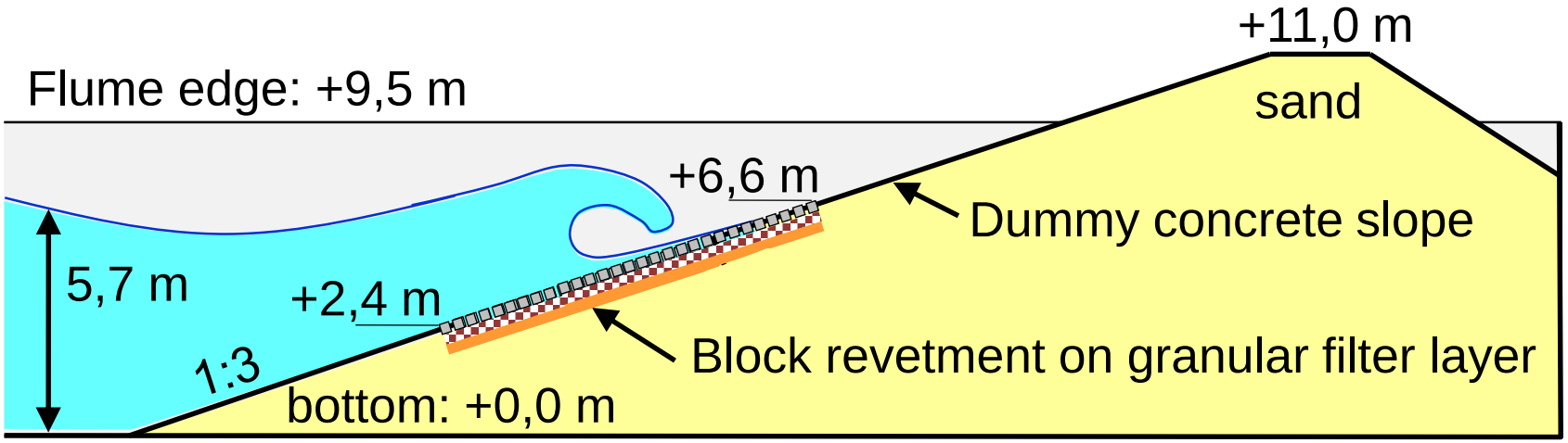
Test set-up and test programme

Scale: 1:2.



Test programe:

- Short duration tests (1000 waves) (increasing Hs until damage):
  - Wave steepness = 0,02
  - Wave steepness = 0,04
  - Long duration test: 26 hours

$= H_s / L_{op} = \dfrac{H_s}{\frac{g}{2\pi} T_p^2}$

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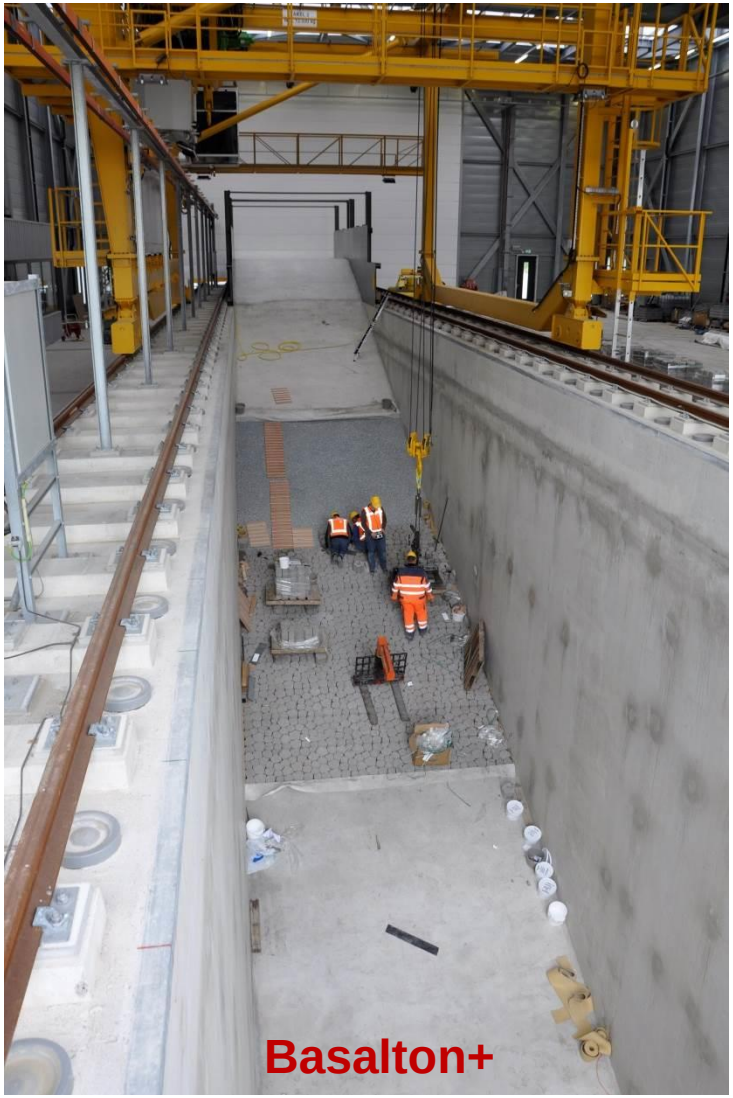
Model construction in Delta Flume



Delta Flume:

- Length: 300 m
- Width: 5 m
- Depth: 9.5 m
- Max H_s: 2 m

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Test in Delta Flume

Step-by-step increasing H_s until damage (blocks washed-out)

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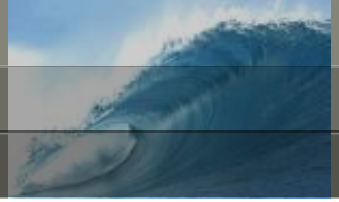
Results



- 3 conditions at which damage occurred, resulting in 3 correction factors (f) for the calculation model
- Based on the average value and the standard deviation a safe value was derived
- Focussing on the strength component ‘interaction of the blocks’

Ronaton:	**f = 1.19**	Basalton:	f = 0.98
Hillblock:	**f = 1.19**	Ronataille:	f = 0.89
Basalton+:	**f = 1.18**	Testblok:	f = 0.85
C-Star:	**f = 1.17**	Verkalit-GOR:	f = 0.70
Verkalit-mgv:	**f = 0.89**		

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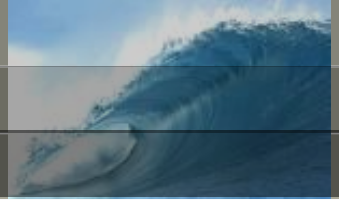
Conclusions



- Large scale tests worked very well to compare the various block revetments presently on the market
- Stimulating innovations in block revetments
- Well performing revetments:
  - Good interaction between the blocks
  - Low to very low leakage length
- Disappointing revetments:
  - Poor interaction between the blocks, mainly because gravel in joints washed out

Future research: better understanding of role and performance of gravel in the joints.

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