Predicting The Reshaping Of Temporarily Exposed Bunds With XBeach-G

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Berm, Dune, and Bluff Erosion

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Introduction

XBeach-G

Bontrup Tests

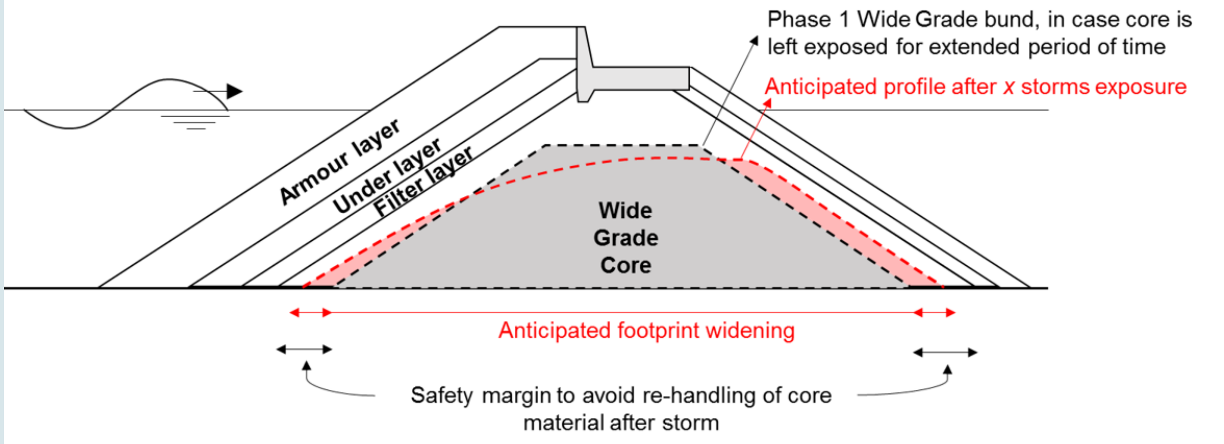
Merli Tests

Conclusion & Further Research

- During coastal construction works damage occurs due to the phased construction

- Temporary exposed bunds (breakwater core)
  - Wide graded material
  - Build in bulk

- How much reshaping will occur?



- Prediction of damage
  - Van der Plas et al. (ICE 2017, Liverpool) has performed several physical model tests on 0/200mm fine wide grade material (alternative to quarry run) and has compared this with the existing literature.

→ BREAKWAT (based on Van Der Meer formulae) gives reasonable estimates for emerged structures.
→ Present study: XBeach-G

- Prediction of storm hydrodynamics and hydrology on gravel beaches in order to predict the morphodynamic response of gravel beaches during storm conditions.
- Validated by laboratory test and in-situ measurements of natural gravel beaches.
- Able to reproduce berm building to barrier rollover.

!! Current research has steeper slopes, wide graded material and bigger rock sizes.

- Nielsen 2006 sediment transport

$$u_* = \sqrt{\frac{f_s}{2}}\left(\cos(\varphi)\,u + \sin(\varphi)\frac{\partial u}{\partial t}\right)$$

Friction velocity

$$\theta = \frac{u_*^2}{\left(\frac{\rho_s - \rho}{\rho}\right) g D_{50}} \cos(\beta)\left(1 \pm \frac{\tan(\beta)}{\tan(\phi)}\right)$$

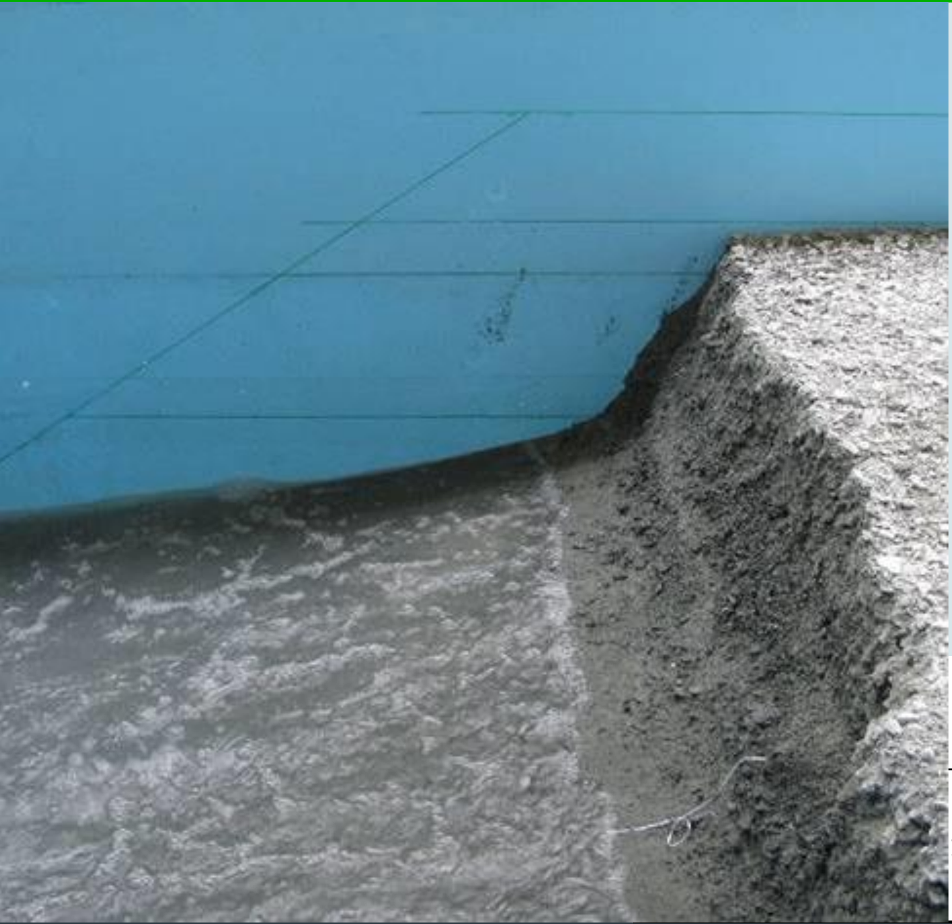
Shields parameter

$$q_s = 12(\theta - 0.05)\sqrt{\theta}\sqrt{\left(\frac{\rho_s - \rho}{\rho}\right) g D_{50}^3}$$

Sediment transport

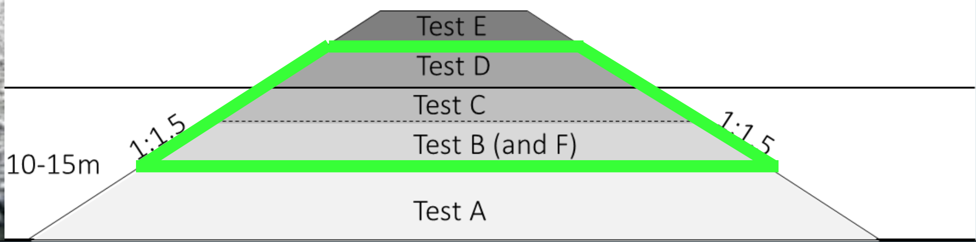
- Sediment friction factor f_s (0.005 – 0.025). Default 0.01
- Phase lag φ. For sand 35 – 45° (±10 – 20°); estimated for gravel (20 – 30°)
- Angle of repose Φ (35 - 45°). Default 35°

Bontrup - Test program



- Physical model tests
  - 0/200mm rock (D_{85}/D_{15} = 10-20)
  - D_{n50} = 46mm
  - Scale 1:10

Layout	Crest width [m]	Freeboard [m]
B	30	-3
C	21	0
D	12	3



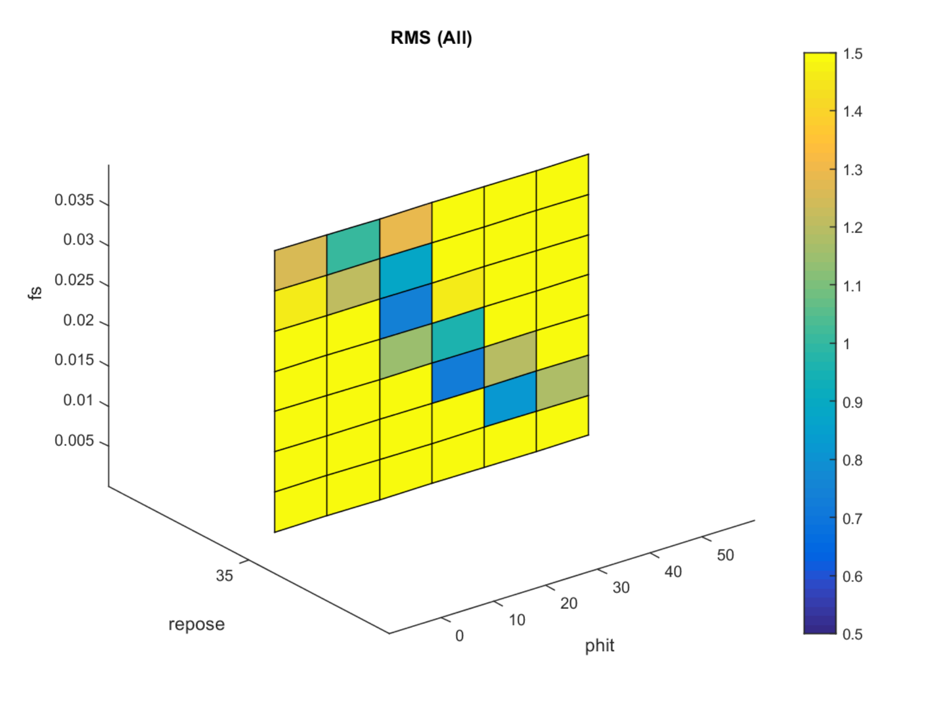
Bontrup - Test program

- Wave conditions

Condition	H_{m0} [m]	T_p [s]
150	1.50	6.2
200	2.00	7.2
275	2.75	8.4
350	3.50	9.5

- No damage repair in between tests but profile measured after every wave condition.

Bontrup – Calibration factors



- Root Mean Square RMS (optimal is 0)
- Coefficient of determination R^2 (optimal is 1)

Conclusion:

- Repose angle has little influence
- Optimum can be found with for all profiles based on end profile (R^2=0.96 RMS=0.71):

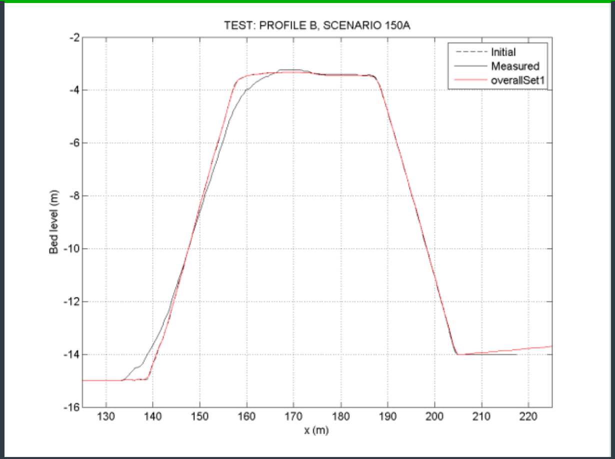
f_s =0.015

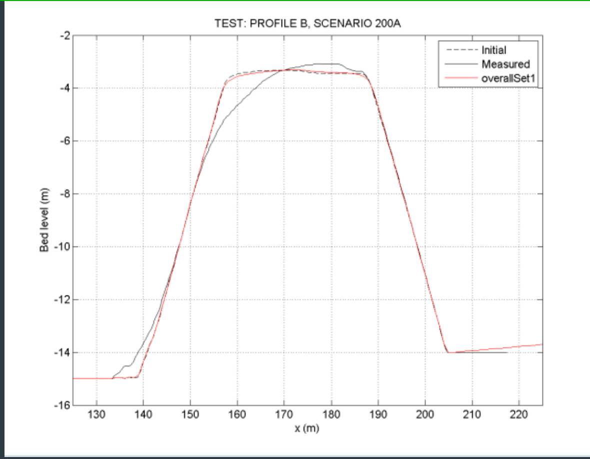
φ = 30°

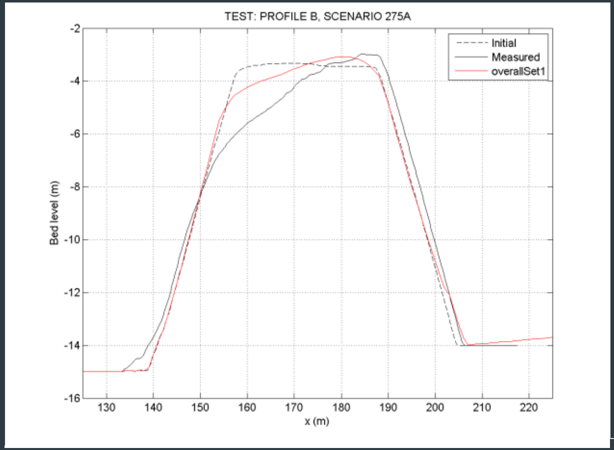
Φ = 35°

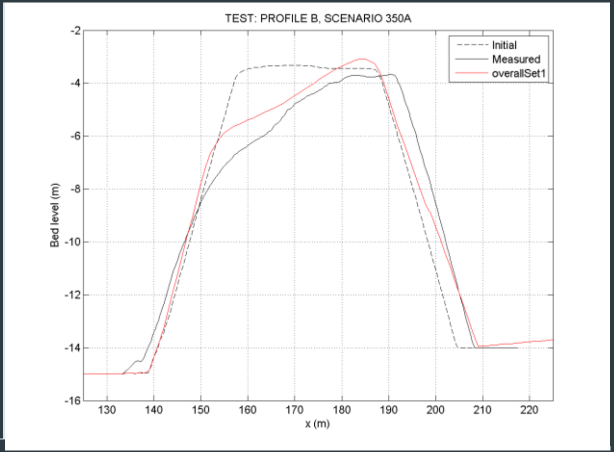
Bontrup - Results

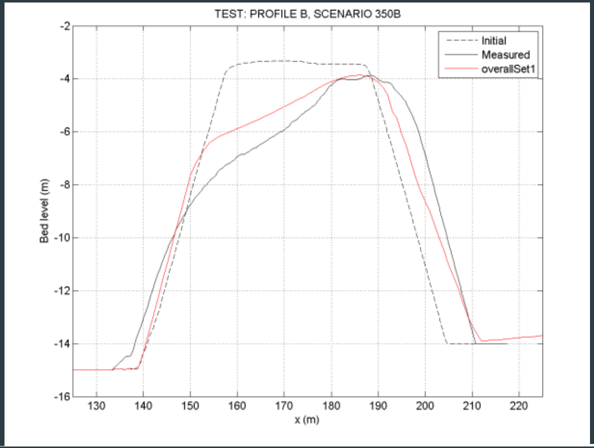
- Submerged section
  - Optimum: (R^2= 0.95 RMS= 0.91)



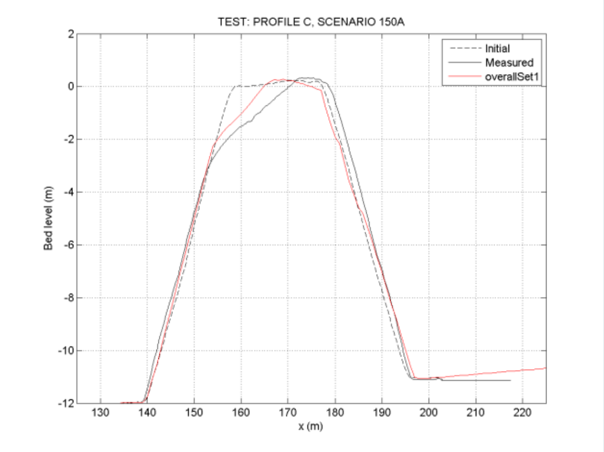


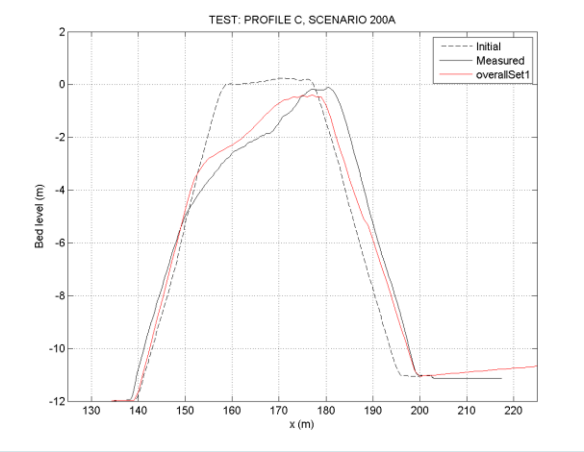


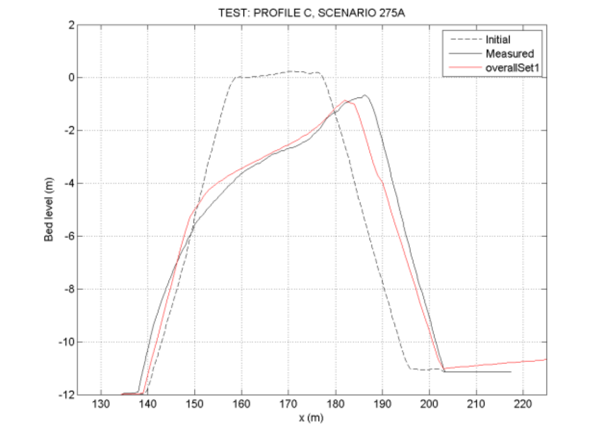


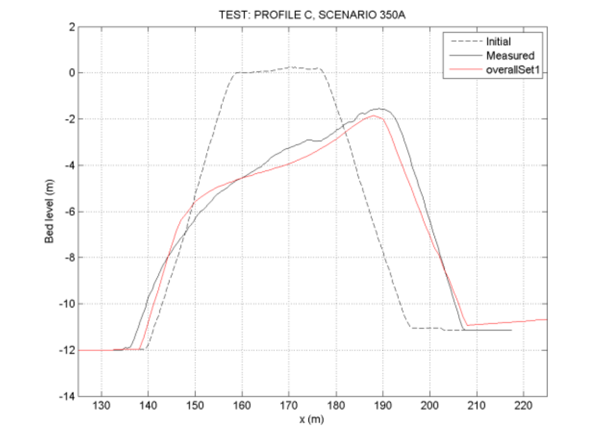


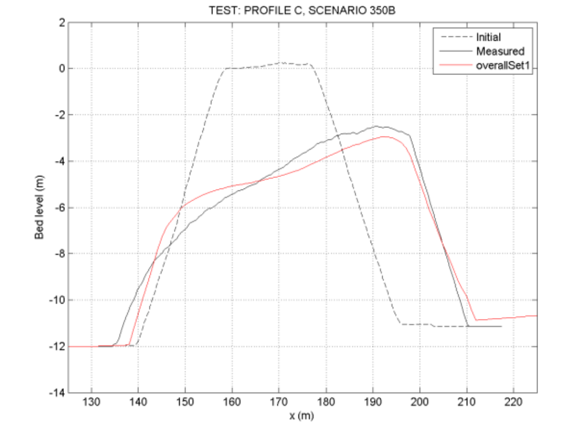
- Crest at the waterline
  - Optimum: (R^2= 0.96 RMS= 0.61)





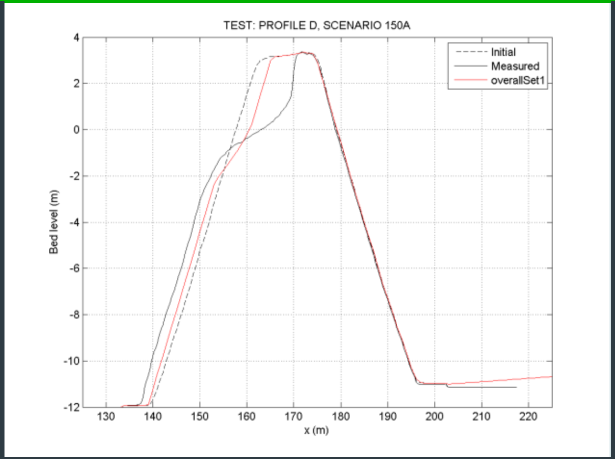


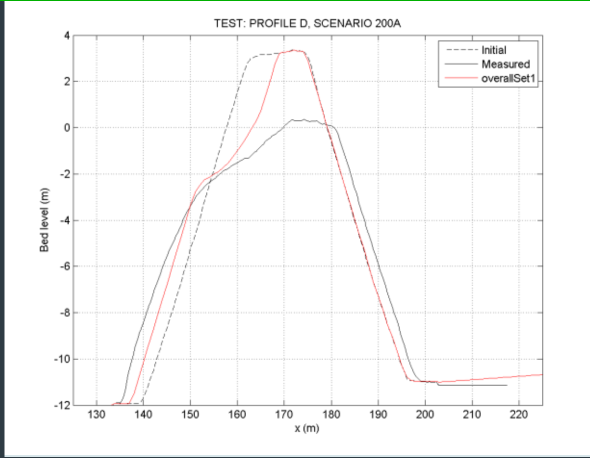


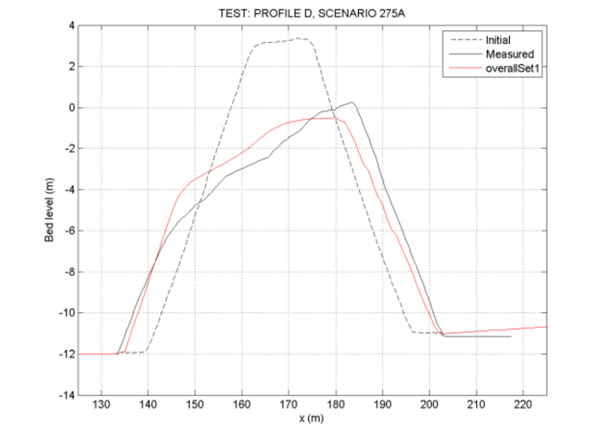


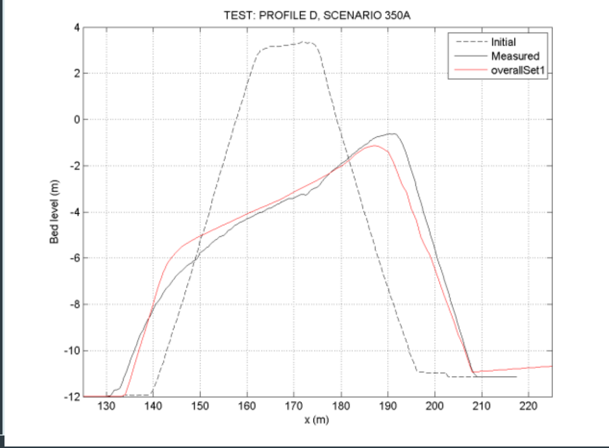
Bontrup - Results

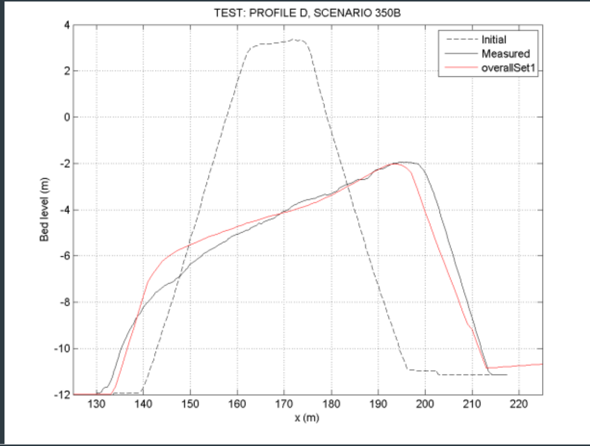
- Emerged structure
  - Optimum: (R^2= 0.96 RMS=0.61)



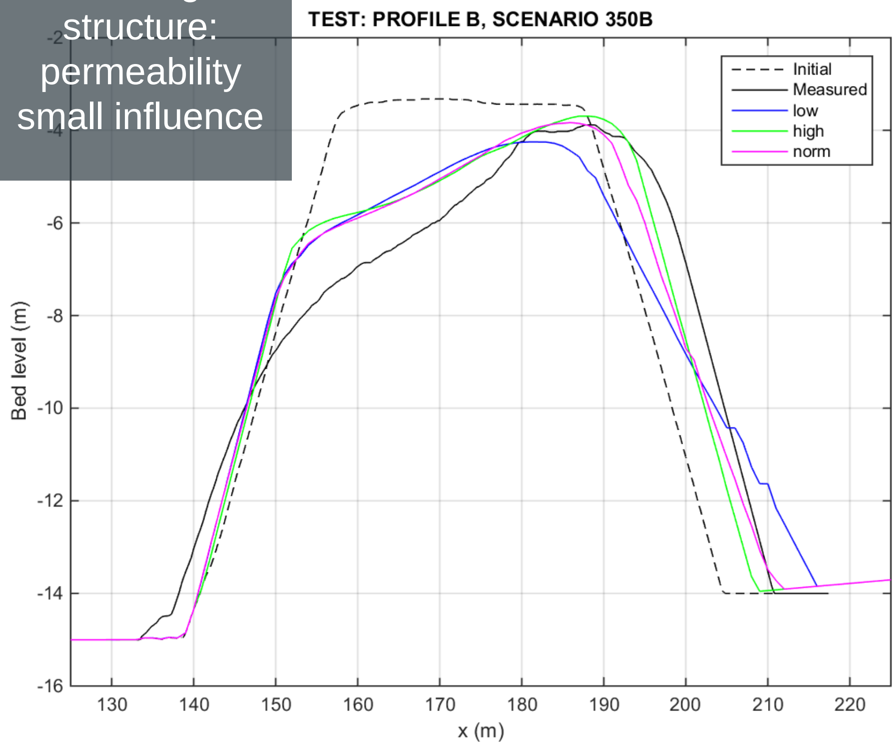




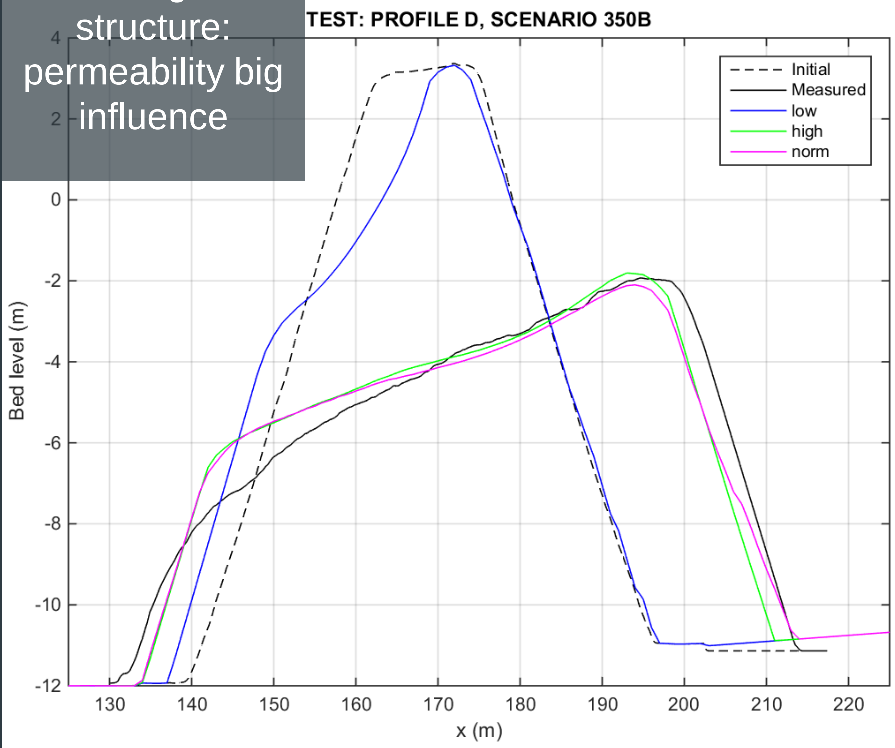




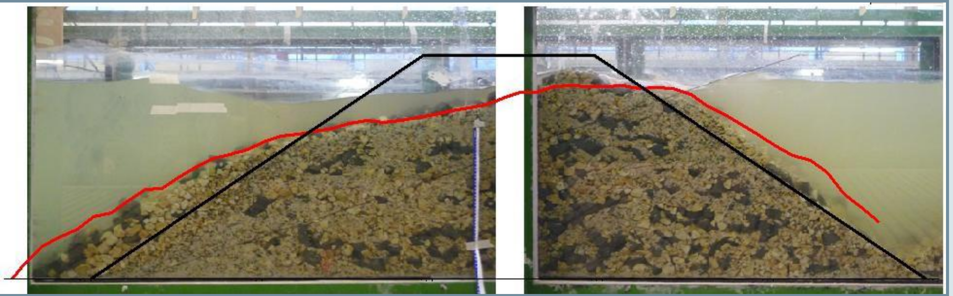
Submerged structure: permeability small influence



Emerged structure: permeability big influence



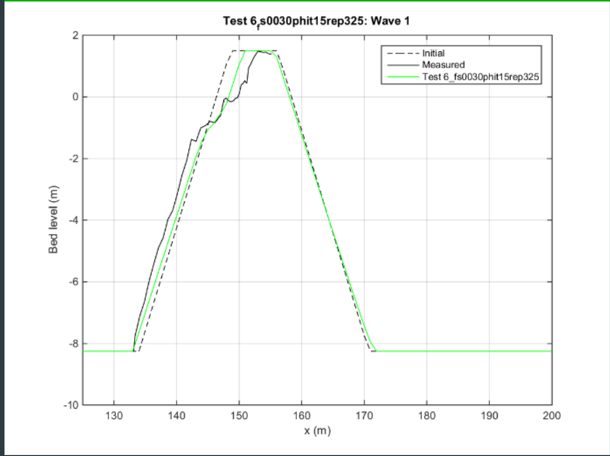
Merli – Test Program

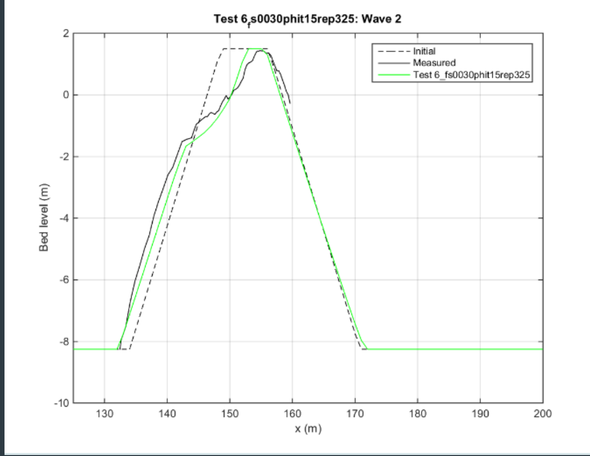


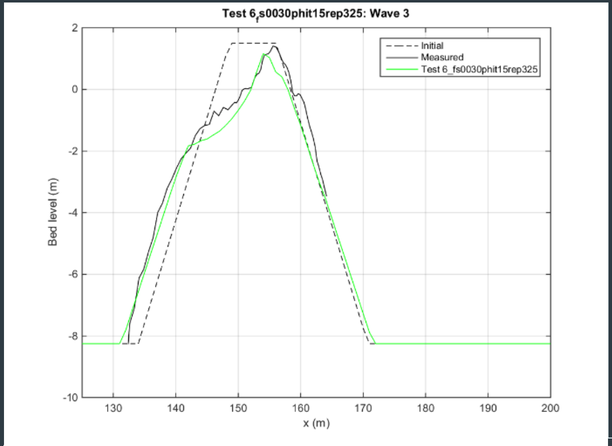
- Bigger rock size → Quarry run
- Wide grade: D_{85}/D_{15} = 17.7
- D_{n50} = 165mm
- Hs ≈ 1.0m
- Emerged section

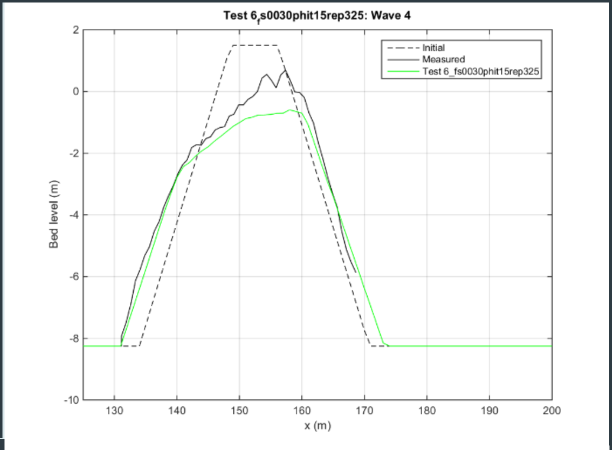
Merli - Results

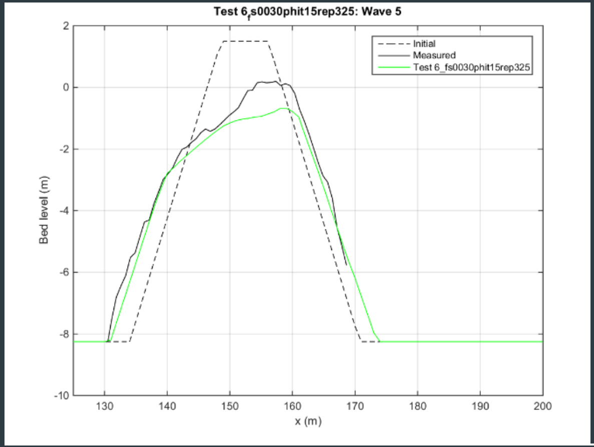
- Optimum last wave attack: (R^2= 0.98 RMS= 0.54)
  - f_s =0.02
  - φ = 20°
  - Φ = 32.5°











Comparison calibration Merli-Bontrup

- Higher sediment friction factor can be explained by the more flacky rock that was used during the Bontrup tests.
- When using a lower phase lag in combination with a higher sediment friction factor similar RMS results are retrieved → two optimums
- Repose angle has again a low influence.
- Same settings as for the Bontrup tests were used → intermediate steps not represented well (lower wave attack)

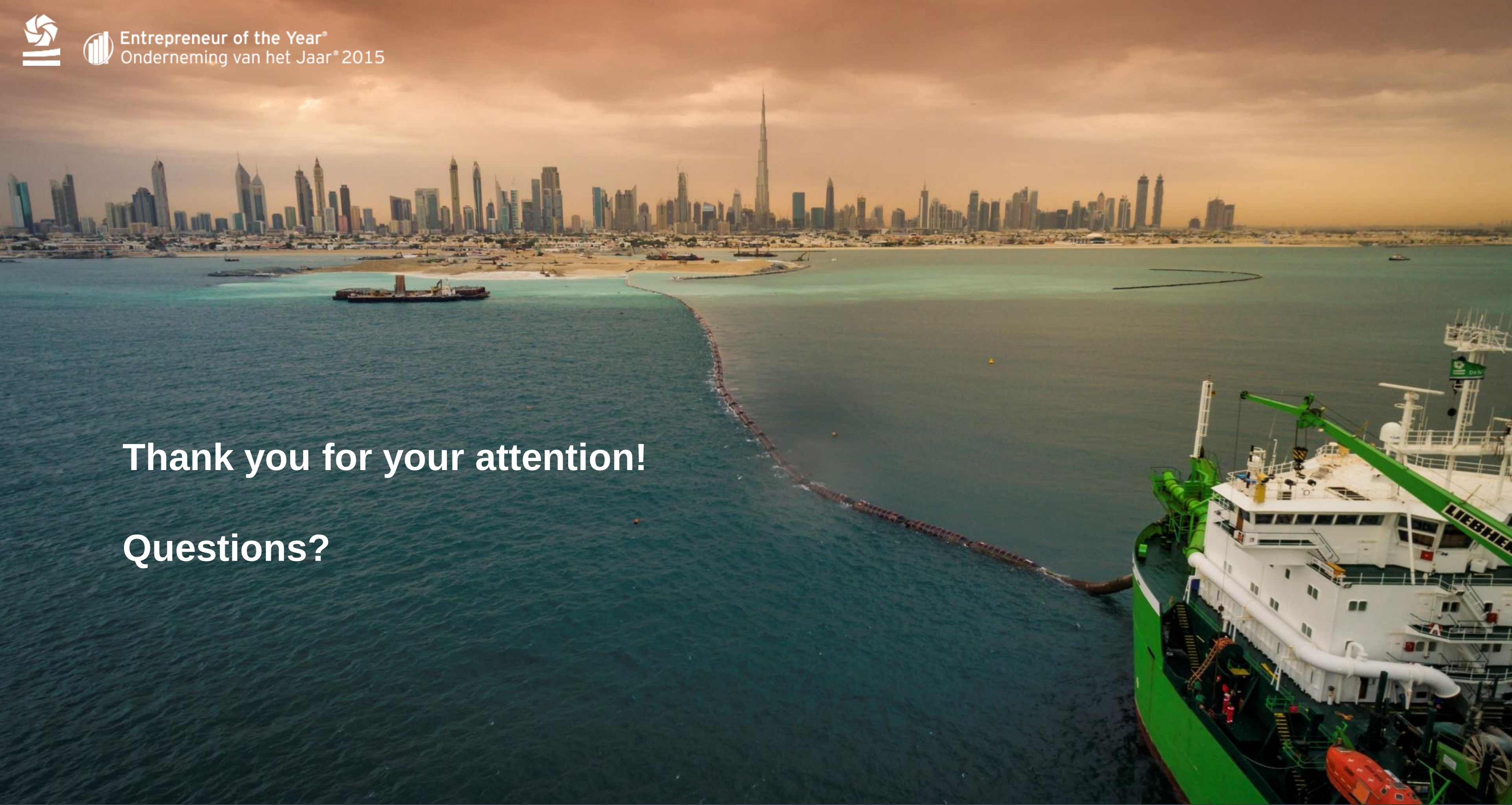
Calibration parameter	Bontrup	Merli	Default XBeach-G
f_s	0.015	0.02	0.01
φ	20°	20°	20 – 30°
Φ	35°	32.5°	35°

Conclusions:

- Good prediction with Xbeach-G of wide-graded material. Calibration helps to find an optimum.
- Using recommended values for gravel the behavior of wide graded material is well reconstructed for the heavier storm attack.
- The anticipated footprint widening is well reproduced for the emerged section.
- While calibrating also intermediate steps (lower wave attack) should be considered.

Further research:

- Influence of permeability.
- Reproducing several tests from Merli (different slopes and different gradings).
- Calibration based on Van Rijn → better prediction of lower wave attack stability?



Thank you for your attention!

Questions?