



Hydraulic stability and overtopping performance *of a new type of regular placed armor unit*

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What is this new armor unit?



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XblocPlus



- Regular placed
- Single layer
- Interlocking
- Unreinforced concrete
- Breakwater and shore protection armor unit





Background



Random placement: Good density



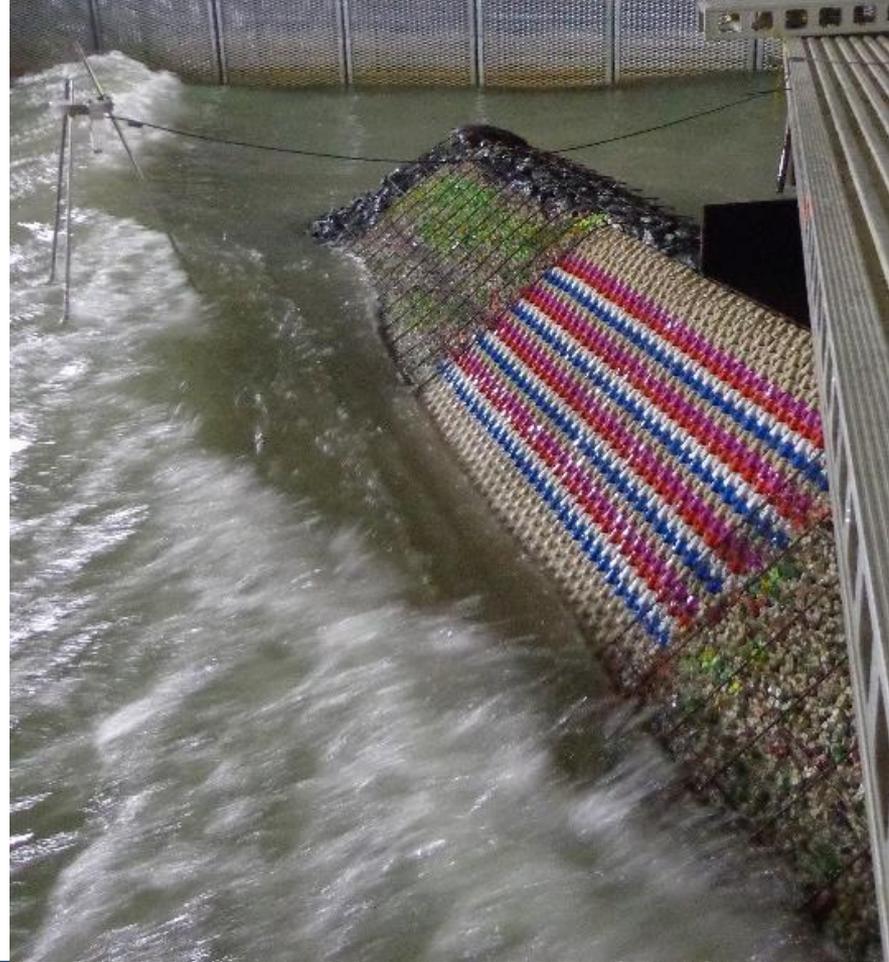
Regular placement: High density

Physical model tests

In total more than 600 tests

of which:

- >400 tests with the final shape
- 35 3D model tests ($\theta = 0^\circ$, 30° and 60°)
- More than 300 overtopping tests



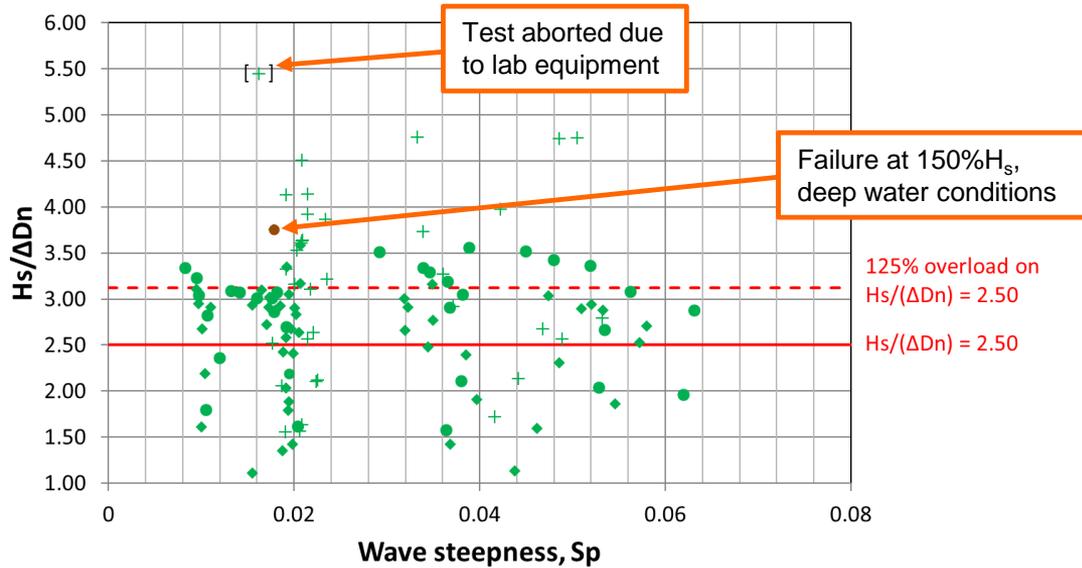
Physical model tests

Tested parameters include:

- Wave steepnesses between 0.01 to 0.06
- Wave heights from $60\%H_s$ to $250\%H_s$
- Slope inclinations of 1:2, 2:3 and 3:4



Hydraulic stability for all tests



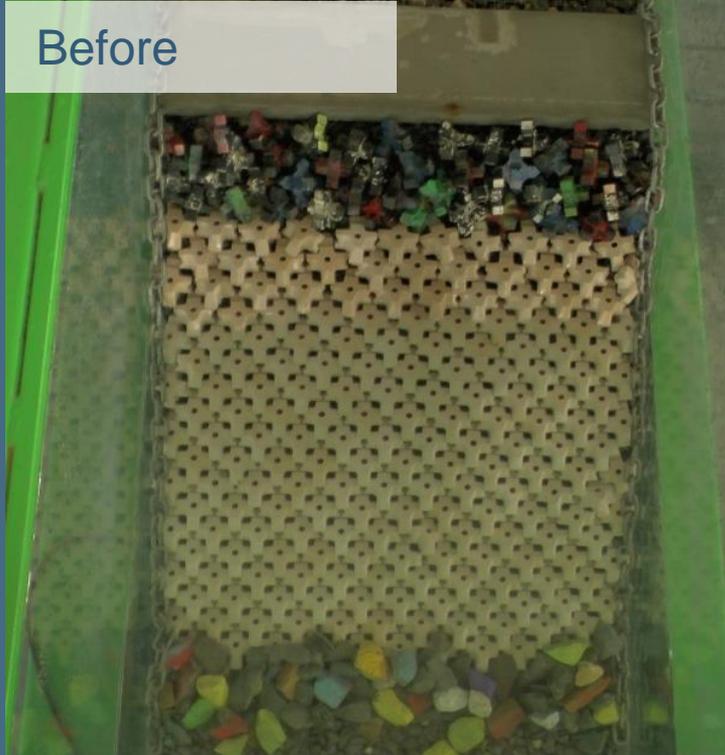
Design equation:

$$\frac{H_s}{\Delta D_n} = 2.5$$

- $H_s / \Delta D_n = 2.50$
- - 125% overload on $H_s / \Delta D_n = 2.50$
- ◆ no damage all 3:4 slope tests
- no damage all 1:2 slope tests
- damage 3:4 slope (deep water)
- + no damage all 3D tests

Failure deep water test

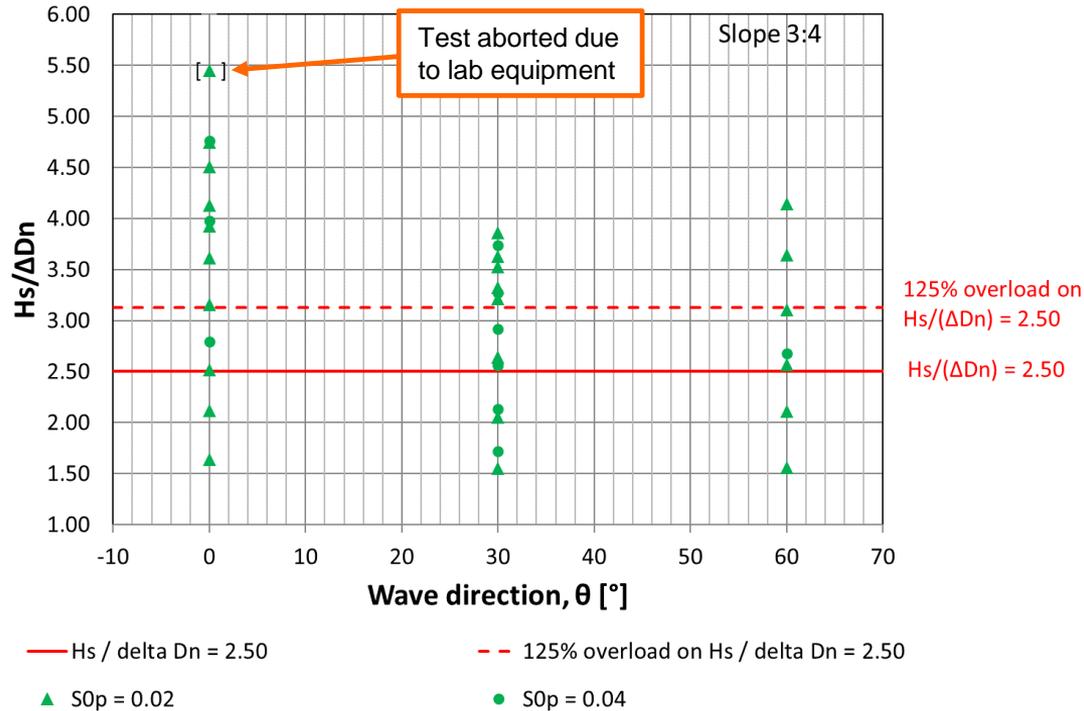
Before



After 150% H_s with deep water conditions



Hydraulic stability 3D model tests



3D model tests

200% H_s overload
conditions

$S_0 = 0.06$, $\theta = 0^\circ$



Resilience of damaged armour layer

Start of testing

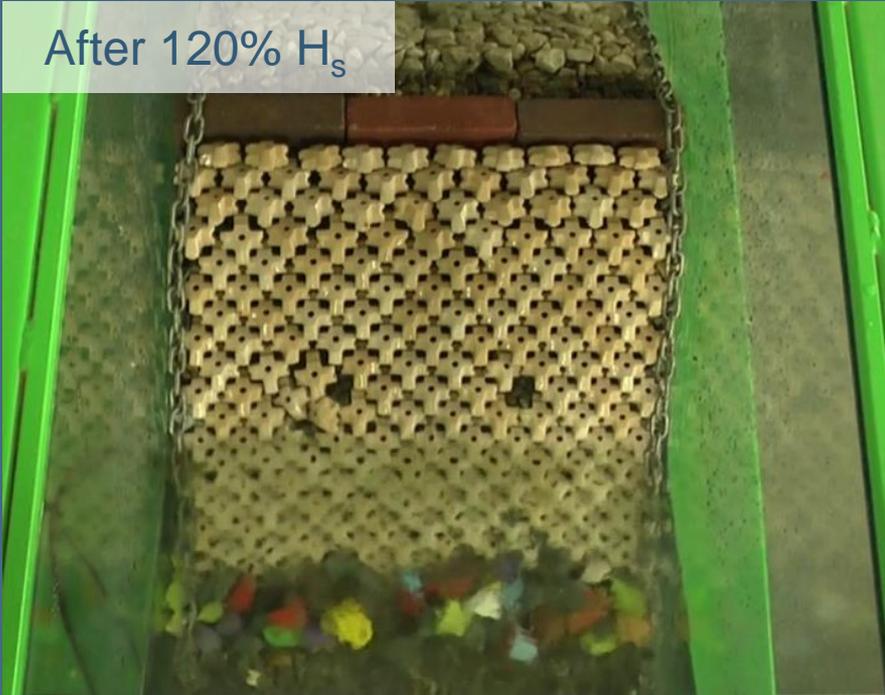


After 100% H_s



Resilience of damaged armour layer

After 120% H_s



After 140% H_s



Resilience of damaged armour layer



Hydraulic stability - conclusions

Large safety margin

between chosen stability number and tested stability

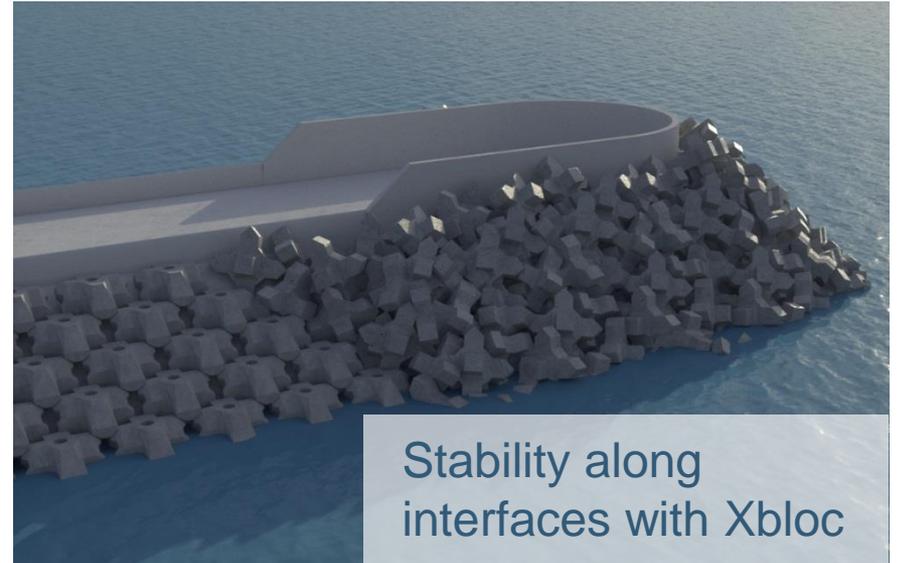
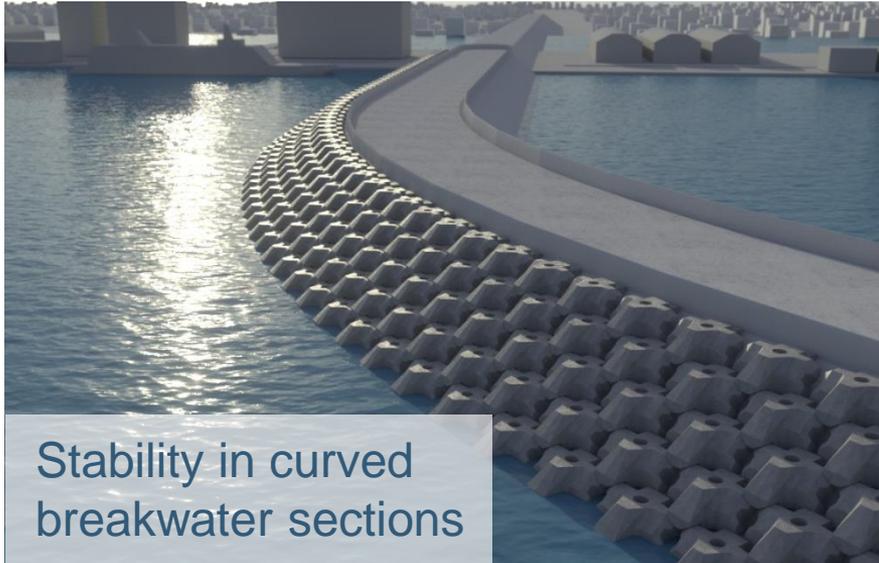
No rocking observed

during testing



Hydraulic stability - conclusions

Still to be tested:

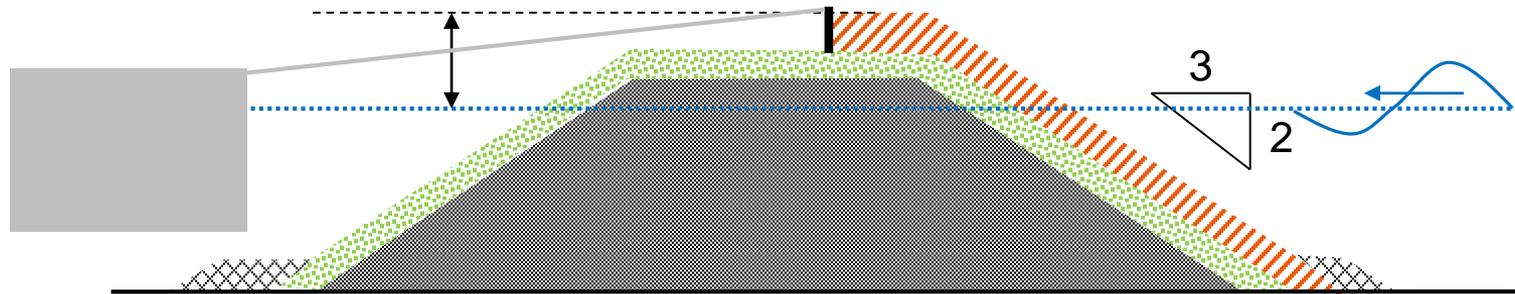


Roughness coefficient

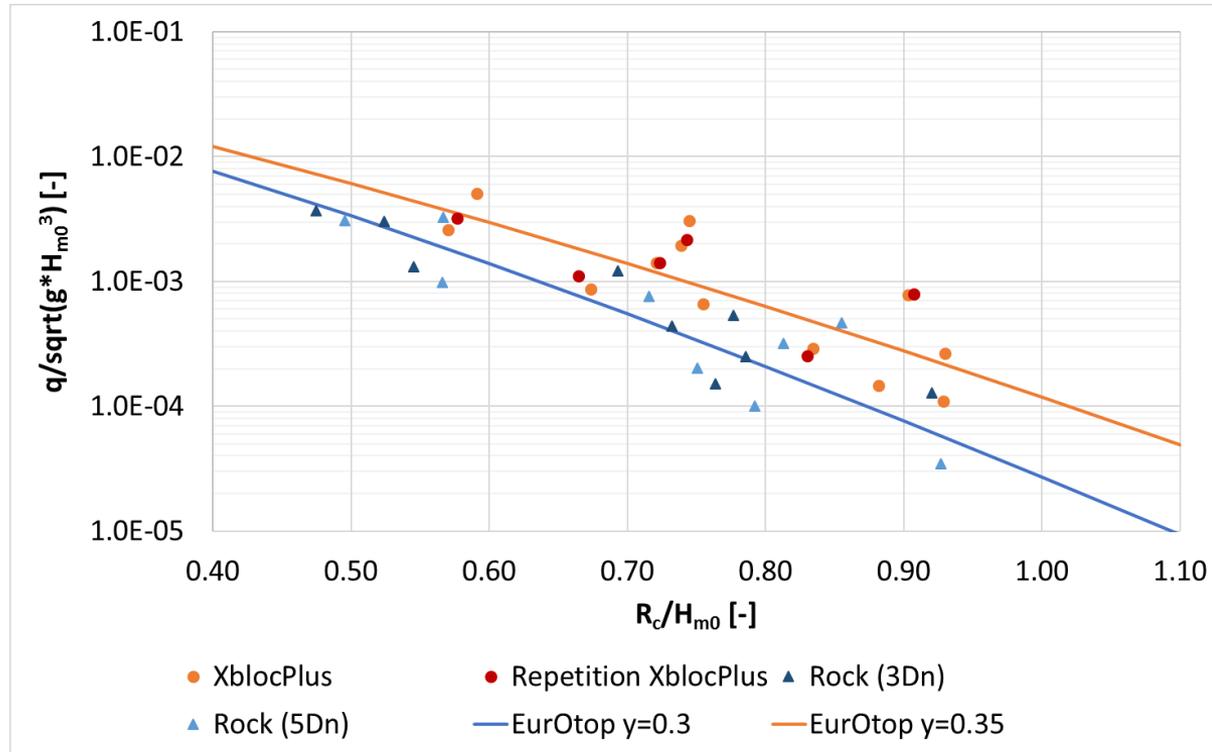
Relative freeboard:
0.47 – 0.93

Wave height:
41% - 92% $H_{s,design}$

Wave steepness:
0.01 – 0.04

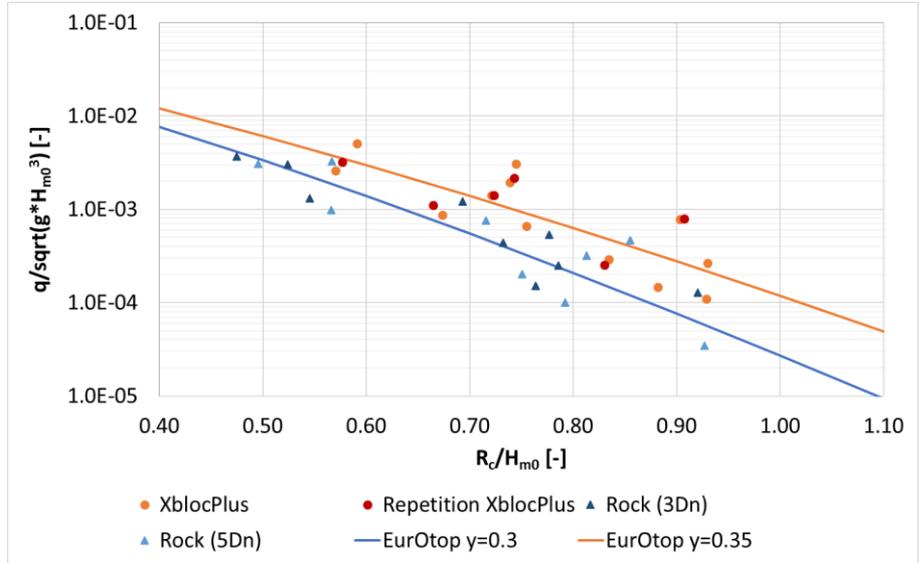


Roughness coefficient



Roughness coefficient

- Roughness coefficient for rock at $3D_n$ and $5D_n$ is $\gamma_f = 0.30$
- Roughness coefficient for XblocPlus (all tests) is $\gamma_f = 0.35$
- Correction factor for rock $c_f = \frac{0,40}{0,30} = 1.29$
- Roughness coefficient XblocPlus $\gamma_f = 0.45$



Thank you for your attention!



Questions?



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