STABILITY OF XBLOCPLUS ARMOUR LAYERS AFTER INITIAL DAMAGE

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INTRODUCTION

Single layer interlocking armour units are commonly applied for protection of breakwaters and seawalls as they are more cost efficient and more sustainable than traditional double layer armouring. However, after initial damage single layer armouring is considered more vulnerable than double layer armouring. Therefore single layer armour units are mostly applied with relative large safety margins.

XblocPlus, an interlocking single layer armour unit that is placed with uniform orientation was introduced by DMC in 2018. The unit is applied with a large safety margin as physical model test were performed without damage up to stability numbers of $Hs/\Delta D_n$=5.5 whereas a design stability number of $Hs/\Delta D_n$=2.5 has been adopted. Nonetheless the behaviour of an XblocPlus armour layer after initial damage is has been investigated by physical model tests with broken model units.

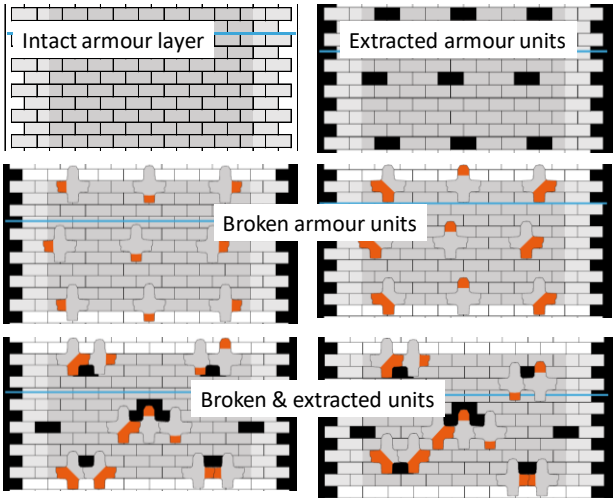

Figure 1 – Tested armour layers with and without initial damage (clusters of broken and/or extracted armour units)

EXPERIMENTAL STUDY

Model tests have been performed in the DMC wave flume (Utrecht, NL) with an XblocPlus armoured breakwater (slope 3:4). The design wave height of the XblocPlus units (size 2.9 cm, mass 58.4 g) was H_s = 9.9 cm. The seabed in front of the breakwater was horizontal, the water depth was 44 cm. Tests series were conducted with stepwise increasing wave height (60% to 150% of the design wave height) and with constant wave steepness (0.02 and 0.04).

The tests duration was 1,000 waves (JONSWAP wave spectra).Tests were performed with an intact armour layer (reference tests) and with clusters of broken and extracted armour units of varying size (Fig. 1). Movements (settlements and displacements) were determined for all armour units and for each test series to assess the impact of broken and extracted units on the overall stability of the armour layer.

Figure 2 – Breakwater slope with clusters of extracted and broken XblocPlus units

EXPERIMENTAL RESULTS

Fragments of broken XblocPlus units were washed away and came to rest at the breakwater toe. Broken armour units were not extracted even in 150% overload conditions if surrounded by intact armour units. Broken armour units were extracted in some cases from clusters of broken or extracted units. Little or no rock material from the underlayer was washed out through the largest gaps tested in the armour layer. Virtually no increase of armour unit movements was observed next to smaller gaps in the armour layer. Increased movements of armour units were observed near larger gaps but did not result in damage progression (extraction of additional armour units) with up to 150% overload conditions.

XblocPlus armour layers (with uniform orientation) respond differently to initial damage than interlocking armour units with random orientation. The latter are moving and re-arranging in order to bridge a gap in the armour layer (de Rover et al., 2008). XblocPlus units in contrast hardly move and nonetheless maintain the hydraulic stability of the damaged section. Details of the experiments and findings as well as implications for design and maintenance of breakwater armour layers will be discussed in the final paper.

REFERENCES

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