BREAKWATER STABILITY WITH DAMAGED SINGLE LAYER ARMOUR UNITS

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INTRODUCTION

At breakwater and seawall projects at Port St Francis and Scarborough breakage of single layer armour units was observed. It is generally assumed that breakage of single layer armour units has a significant negative effect on the hydraulic stability of a rubble mound breakwater. The significant decrease of interlocking capacity and mass of the broken units would lead to displacement of these units and surrounding units. The broken parts of the damaged units would act like projectiles. The waves would “throw” these broken parts back and forth to the armour layer. More armour units may break due to the impact of these broken parts leading to rapid damage progression of the armour layer and finally to failure of the total construction. This damage behaviour has however never been confirmed.

OBJECTIVE

The main objective of this research is to determine the effect of single layer armour unit breakage on the hydraulic armour layer stability and potential damage progression.

PHYSICAL MODEL

A 2-dimensional model of a rubble mound breakwater with a typical cross section is tested in a wave flume at Delft University of Technology. The armour layer consists of model Xbloc armour units with a nominal diameter D_n of 2.77cm and a design wave height H_d of 10cm.

Figure 1 – cluster of broken Xbloc armour units (in red)

From every model Xbloc unit that simulates a damaged unit one nose or leg is cut off. The detached nose or leg is glued back on the unit with a sugar/water solution to place the units in the armour layer. When exposed to water the sugar dissolves again simulating the broken units in reality as close as possible.

TESTING SET-UP

Irregular waves with a Jonswap-spectrum are used during the test series. The wave height is increased from 80% up till 190% of the design wave height at a constant water depth of 0.55m and a wave steepness of 0.045. Different configurations with broken units are tested. 0%, 7.5% or 15% of the units around still water level over a height of $2H_d$ are broken. The damaged units are placed in clusters of 5 units or individual. Their position is varied with respect to the still water line.

EXPERIMENTAL RESULTS

For all test series with broken units start of damage occurred at significant lower wave heights compared to an armour layer with no broken units. However failure occurred at approximately the same wave heights as for an armour layer with no broken units. Increasing the percentage of broken units or number of broken units in a cluster had only a minor additional negative effect on start of damage and failure. The position of the damaged units around the still water line over a height of $2H_d$ gave no difference in influence of the broken units on start of damage and failure. The majority of the detached noses and legs showed little to no movement and stayed in the armour layer or even tend to dig themselves in the first underlayer.

CONCLUSIONS

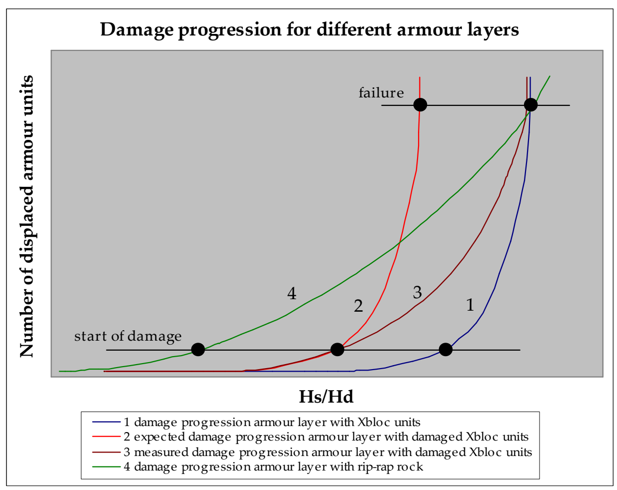

Figure 2 – general damage behaviour for different types of armour layer

The damage progression of an armour layer with damaged units is long and gradual compared to the damage progression of an armour layer with no damaged armour units. This type of damage progression looks like the damage progression of an armour layer consisting of rip-rap rock.

Only a few broken noses and legs showed displacement during the test series. It is therefore unlikely that under influence of the waves the broken parts will act as projectiles damaging other units.