# Introduction of a new coastal protection method - Elastomeric revetments

Dehua Gu

BASF East Asia Regional Headquarters Ltd.
45th Floor, Jardine House, No. 1 Connaught Place, Central, Hong Kong
dehua.gu@basf.com

## INTRODUCTION

Elastomeric revetment is a newly developed method to create a bank and shoreline protection by bonding small riprap or crushed stones with polyurethane (PUR). So far it has been applied successfully over 25,000 sqm on various projects in Germany ("Hamburg Hallig", "Holm Gröde"), in the Netherlands (breakwater revetment in Zuidbout and Petten), in France (canal embankment near Le Havre), and in the UK (open stone asphalt revetment repaired in Holland-on-Sea). This paper briefly introduces some research results related to the stability and environmental reliability of PUR-bounded revetments.

The top layer of an elastomeric revetment consists of individual stones adhered by a polyurethane based 2-component system which coating crushed stones on their surface and reinforce them at their contact points; together PUR-bonded stones creates a monolithic, open-porous, stable and flexible structure, which is cost-effective due to savings in building material: smaller and less stones are applicable in same conditions and the required amount of PUR is in total less than 5% of the total weight of the structure. The raw material of applied PUR consists of ~50% of renewable, re-growing materials and its transparency makes the Elastomeric revetments look the same as naturally set loose rip-rap.

## MECHANICAL PROPERTIES

In order to determine the necessary mechanical properties for design of a PUR-revetment, a number of 3-point and 4-point bending tests had been carried out on beams of Elastocoast[1]; which provided the coefficients needed for elasticity and breaking strength calculation as well as the information on fatigue properties [Gu, 2007a].

## FAILURE MECHANISMS

The failure mechanisms of a slope revetment include wave impact, uplift (pressure difference), abrasion, structure change (settlement, etc.) and so on; some of these factors regarding elastomeric revetments have been identified while some of them still need further study; a general introduction is given in the following paragraphs.

[1] Elastocoast® (www.elastocoast.co m) is a trademark of BASF

To avoid stones broken out of the structure by impacts of waves and currents, strong adhesion between individual stonescreated by polyurethane is proved to be sufficient; while the influence of expanding force generated by ice to the open structure still needs to be clarified.

Generally, damage observed from loose rocks and placed stones will not occur to elastomeric revetment due to the high bonding strength and open-porous structure which results in a high permeability (in the order of 0.1 $m^3/m^2s$, similar to loose rip-rap and higher than gabions) and then significant reduction of pressure difference [Gu, 2007b].

Based on similarities of materials properties, two calculation methods for design reference are introduced: GOLFKLAP [De Looff, 2006] and the stability analysis formulation of gabions [Pilarczyk, 2000]. Even regardless the positive factor of high permeability of PUR-bonded stones layer, results shows generally around 20 cm layer of elastomeric revetment is sufficient for a significant wave height of 1-1.5 m [Verhagen, 2009].

However, the exact reduction of layer thickness due to high permeability isnot known until now. A real scale tests in the Large Wave Flume in Hannover have been planned in March 2009 to resolve this problem.

Tests and investigations have been done to verify the system's resistance to abrasion. A laboratory experiment shows the abrasion resistance of elastometric revetment was lower than artificial concrete blocks but considerably higher than open stone asphalt [Gu, 2007b]. Besides, an overtopping simulator test was done near the Oosterschelde Estuary in the Netherlands; after being flushed 18 hrsby 125 l/ms currents, no damage on the elastomeric revetment could be found [Bijlsma, 2008a]. On the two pilot sites in the Netherlands, the abrasion was measured during a storm season and only about 0.3% stones were eroded from the top layer [Bijlsma, 2009b, Figure 1].

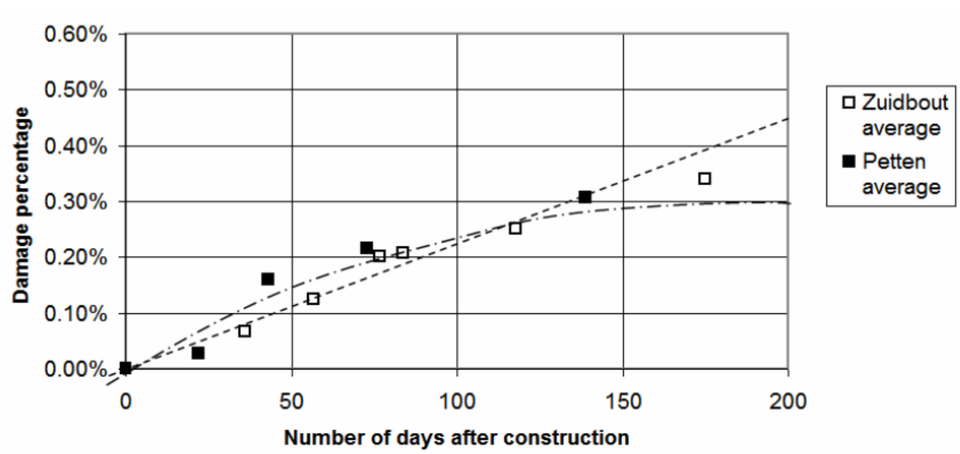


Figure 1. Field tests on abrasion (Bijlsma, 2008b)

Regarding other failure mechanisms, aging tests, UV tests and frost/thaw tests had been done, articles introducing the relative results can be found on the website of supplier of this material, as well as the application and construction method.

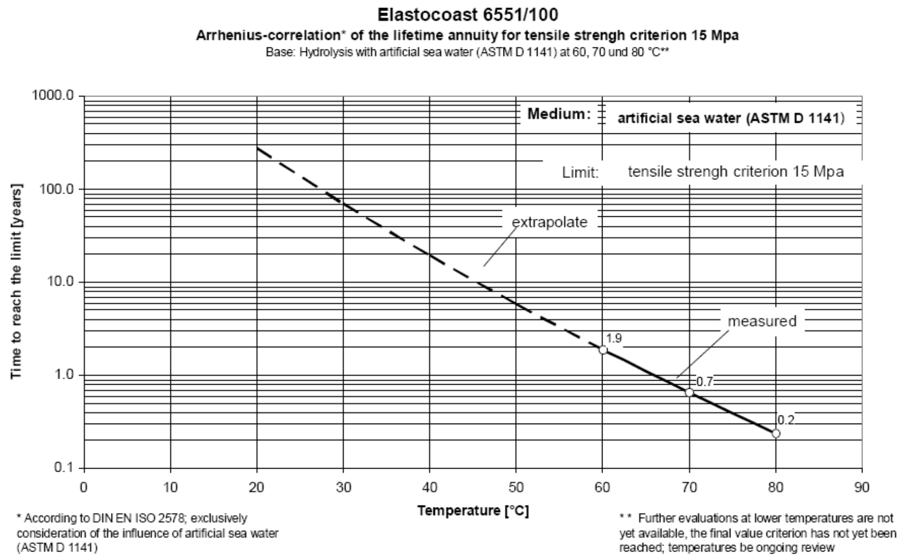


Figure 2. Arrhenius-correlation of Elastocoast

## ENVIRONMENTAL ASPECTS

Both laboratory tests and field tests have been performed to study the colonization of flora and fauna on elastomeric revetments in the Netherlands. Incubator tests done by the University of Amsterdam and Arcadis together showed that after 27 days algae created a biofilm on the polyurethane layer; for the pilots constructed in the Netherlands, various algae (Blidingia minima, Enteromorpha compressa, Fucus spiralis), snails and mussels had colonized revetments only approx. two months after construction [Lock, 2008].

## TAKE HOME MESSAGE

Elastomeric revetment is a newly developed method to create a bank and shoreline protection by bonding small riprap or crushed stones with polyurethane (PUR). Elastocoast® bonded stones creates a monolithic, open-porous, stable and flexible structure, which is cost-effective due to improvement in construction efficiency, savings in building material and its handling cost. The raw material of applied PUR consists of ~50% of renewable, re-growing materials and its transparency makes the Elastomeric revetments look the same as naturally set loose rip-rap.

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