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Polyurethane Bonded Revetments With Elastotite® ROCK GLUE

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Permeable Paving Solutions

Agenda

- Polyurethane bonded aggregate (PBA) revetment overview
- PBA Installation process
- Review of various revetment technologies
- Examples of PBA in use
- Questions



What is a Polyurethane Bonded Aggregate (PBA)?

- PBA is innovative solution developed for shoreline protection and erosion control
- **Stone** fixed together at contact points with **polyurethane**
- Structure is 3-dimensionally **stable, rigid structure**
 - ▶ Open porous
 - ▶ erosion-resistant
 - ▶ environmentally sound



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 **TU Delft** Delft University of Technology

 **TUHH**
Technische Universität Hamburg-Harburg

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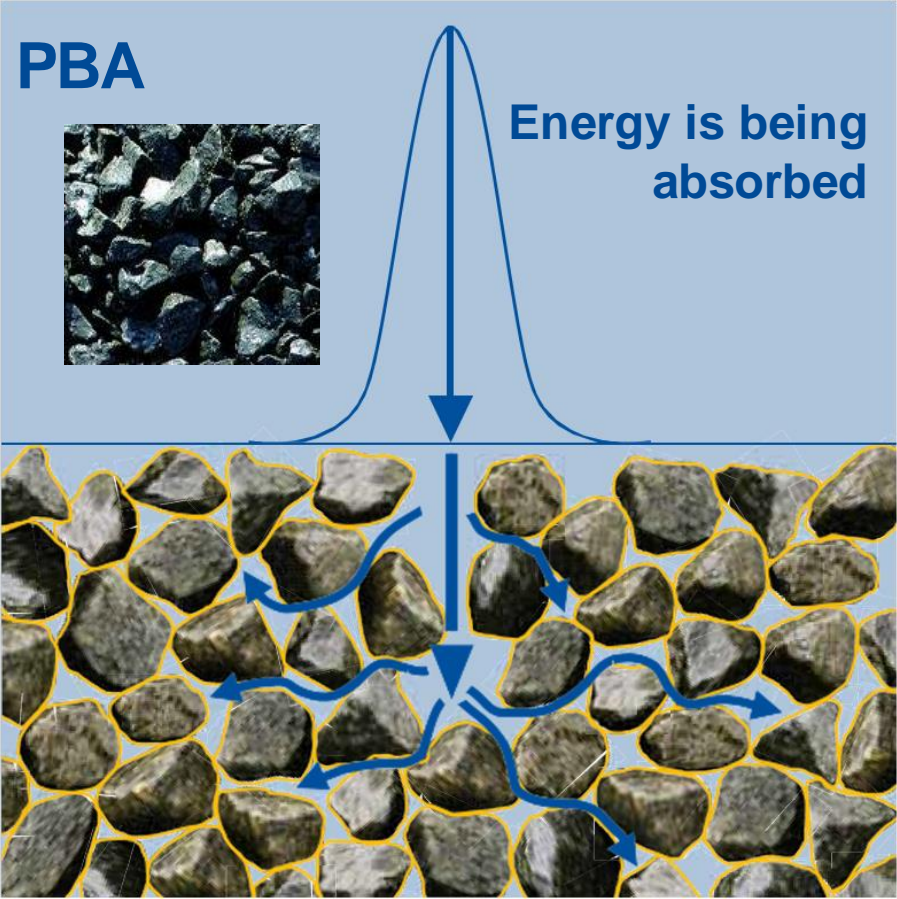
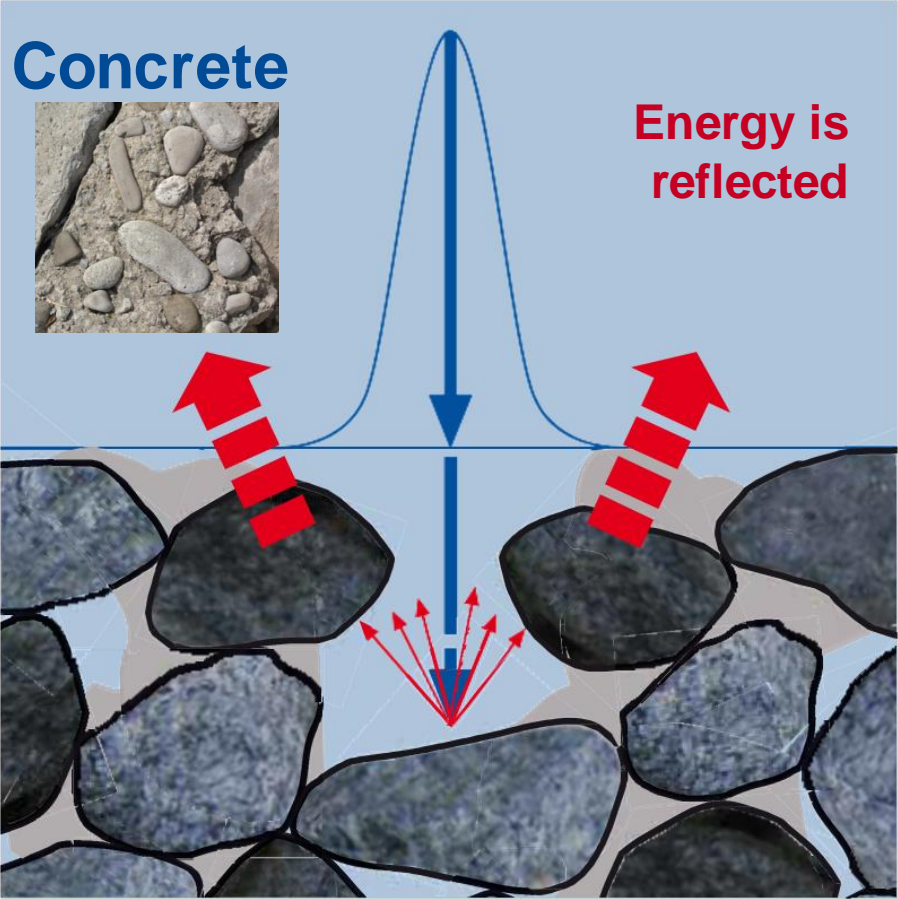
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Advantages of PBA With Elastotite® ROCK GLUE



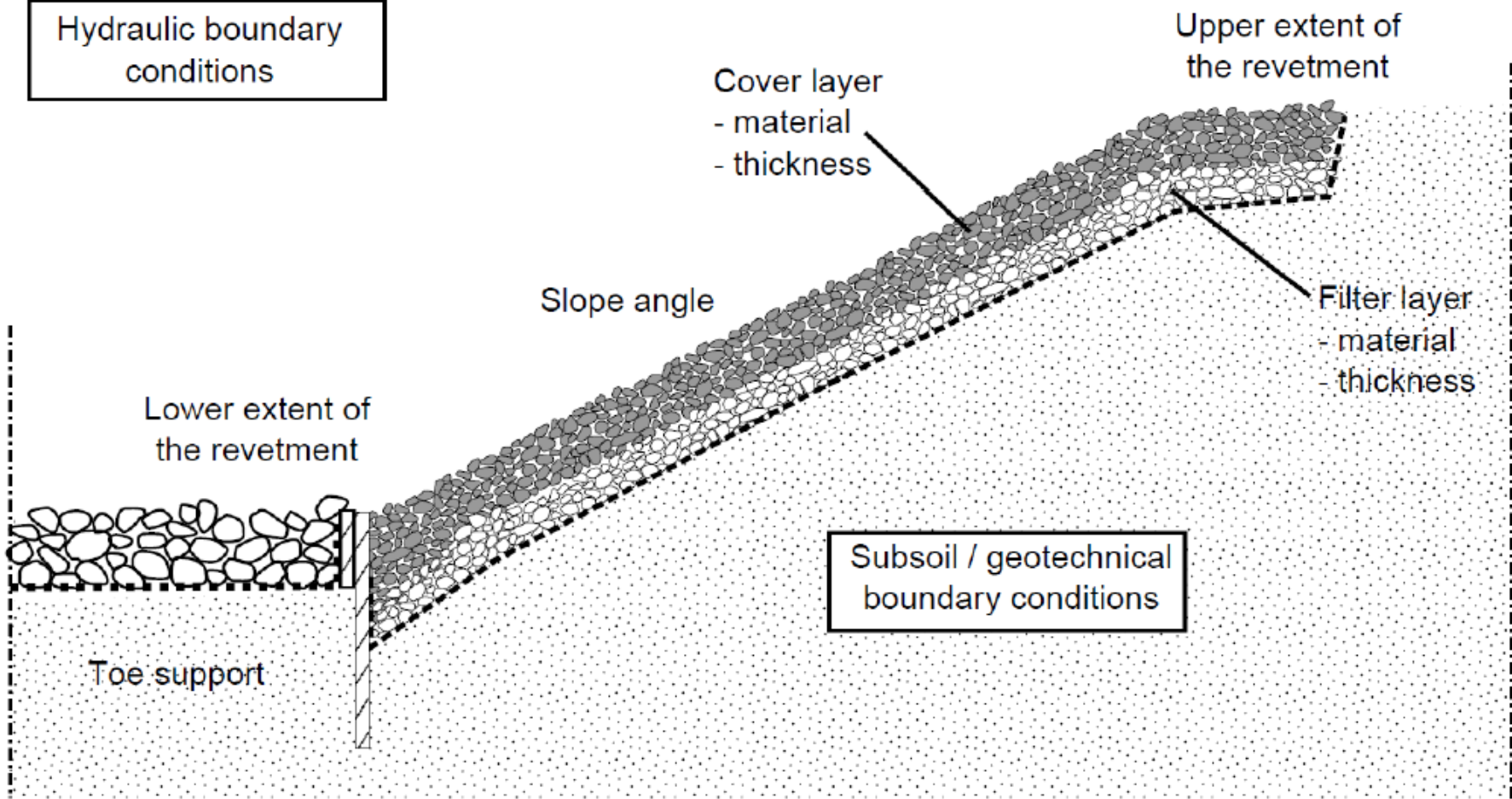
- High porosity and permeability
- Resistance to heat, cold, and UV
- Ecologically compatible
- Can be revegetated
- Cost effective
- Easy to install
- Can install under water
- Large range of applications

Why open poured structures are important?



Benefit: Reduced water energy, excellent freeze/thaw performance

Revetment Made With ROCK GLUE



ROCK GLUE Reduces wave run-up

Up to **50%** reduction*



PBA

Nonporous Revetment

*Average: 35% compared to smooth, nonporous revetments

ROCK GLUE Durability – Wave Overtopping



PBA with ROCK GLUE was tested as most stable structure for overtopping. Structures with & without grass vegetation suffered significant damage at smaller discharge intensities.

Never before has a revetment withstood a load of 125 l/m/s (13.5 ft³/s per ft)

ROCK GLUE Durability

Able to withstand heavy weight
of about

20 tons



Freeze / Thaw Resistance of ROCK GLUE

Sufficiently resistant against freeze/thaw (EN 13383-2)

Dagebuehl DE

Completed: April 2010

2000 m² (21.5K SF) with 10 tons ROCK GLUE

Renovation and bank protection



ROCK GLUE Revetment Cure Under Water

ROCK GLUE has been documented to be installed in water up to one meter deep. After mixing and coating with polyurethane, aggregate can be placed & shaped under water.



**Fighting Island 2016
ROCK GLUE covered in sand, still intact
Surrounding loose rip rap displaced**



**Installation: September 2007
First North American pilot project
PU in Coastal Protection**

ROCK GLUE Revegetation Example



Gwanmaedo Island, Korea
(2012)

- Korean National Park Service asked to protect national park area against erosion
- Rock Glue nominated as innovation structure to protect national park area
- 1 year time lapse of revegetation

ROCK GLUE Effects on Aquatic Ecosystem



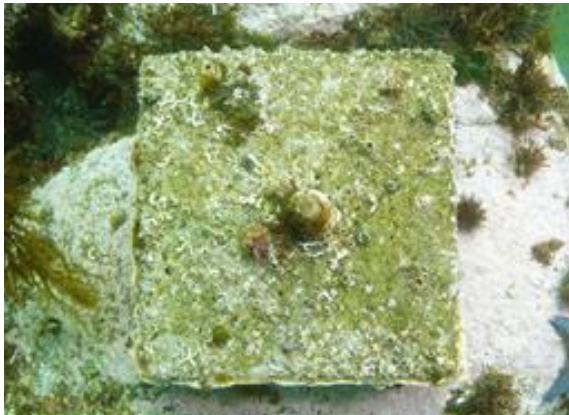
No adverse effects on the aquatic environment observed.

Intron and SGS Institut Fresenius
IMS,

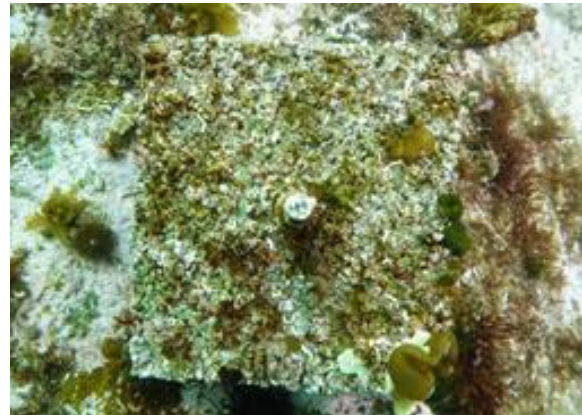
Source: <http://img.gawkerassets.com/img/17eswytmdcktypng/xlarge.png> | <http://www.realmonstrosities.com/2012/09/water-flea.html> | http://www.unsolvedmysteries.oregonstate.edu/microarray_02

Aggregate Size Effect

1 year monitoring of marine plant growth



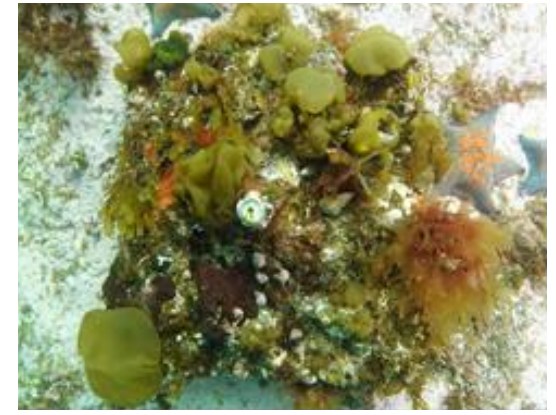
Cement, control



8 mm stone



20 mm stone



30 mm stone

Environmental Recognition

Drinking Water Inspectorate, on behalf of The Secretary of State for Environment, Food and Rural Affairs and the National assembly of Wales, "is satisfied that there is no objection on health ground to the use of this approved product [ROCK GLUE] in the provision of public water supplies"*

ROCK GLUE is drinking water safe per NSF 61 certification



Research at the University of Amsterdam have shown that polyurethane bounded aggregate revetment allows fast ecological recovery as the polyurethane coated rocks form suitable hard substrate for colonization by micro-algae while the open structure provide an attract habitat for vegetation and other organisms.

*please review the Product Approval Confirmation document for more details

Source: <http://www.internationalstudents.nl/university-groningen/> | <http://weheartworld.com/why-drinking-water-is-beneficial-to-your-well-being/>

ROCK GLUE Installation Procedure



Shoreline Revetment Solutions Comparison

RIPRAP



SCULPTED SHOTCRETE



TERRACED CUT STONE



- Commonly used on the Great Lakes; construction and maintenance well understood – good constructability
- Rough permeable surface reduces wave uprush

- Flexibility in the aesthetic appearance of the shoreline
- Can texture surface to create naturalized rock appearance

- Provides access to the water and seating
- Short sections of terraced stone seating can be integrated into another protection option

- Requires larger stone sizes and material quantities to achieve same level of protection as other options
- Poor aesthetics
- Creates barrier to water access

- Must be cast in the dry – poor constructability or expensive
- High maintenance required over time to maintain details in sculpted surface
- Smooth impervious surface increases wave uprush
- May be susceptible to ice and freeze/thaw

- Cut stone needs to be properly treated and maintained to reduce slippery stones at the water level
- Un-natural aesthetics

Advantages

Disadvantages

Shoreline Revetment Solutions Comparison

STEEL SHEET PILE



GROUTED STONE WALL



STACKED STONE ARMOR



- Vertical wall minimizes lake-fill areas
- Common shoreline type

- Creates manicured park edge
- Opportunities to create desired wall profile

- Well understood construction method
- Can form Urban type of Park edge but unnatural appearance

- Impermeable vertical wall increases wave uprush
- Industrial aesthetic
- Barrier to water access

- May be susceptible to freeze/thaw
- Vertical or near vertical slope with limited permeability
- Relatively expensive
- Potential barrier to water access

- Requires sufficient supply of suitably shaped stones
- Relatively expensive
- Barrier to water access

Advantages

Disadvantages

Shoreline Revetment Solutions Comparison

PBA



- Utilizes smaller rock sizes and quantities in comparison with traditional riprap
 - Porous structure allows vegetation to grow without compromising integrity of protection – natural appearance
 - Not susceptible to ice and freeze/thaw
 - Allows pedestrian/small boat access to water's edge
-
- Emerging product in the North American market; construction limited to groups familiar with the product

- Engineered structure that can seamlessly integrate into the natural environment
- Porous and water-permeable
 - ▶ Allows vegetation to establish without compromising integrity of protection
- Strong and resistant to weathering
 - ▶ Suitable for environments with high flow, heavy wave impacts, and ice impacts
- Binder has no effect on water quality and the natural environment. It contains 50% renewable raw materials.

Comparison of Shoreline Options

RELATIVE CONSTRUCTION COSTS, DESIGN LIFE AND MAINTENANCE

| Option | Initial Construction Cost* | Design Life | Maintenance Costs |
|-----------------------|----------------------------|------------------|-------------------|
| Riprap | Low to Moderate | High | Low |
| Sculpted Shotcrete | High | Low to Moderate | Moderate |
| Terraced Cut Stone | High | Moderate | Moderate |
| Steel Sheet Pile Wall | Moderate to High | High | Low |
| Grouted Stone wall | High | Moderate | Moderate to High |
| Stacked Stone Armor | High | Moderate to High | Moderate |
| ROCK GLUE | Moderate to High | High | Low |

*Construction costs assume low cost/ readily available rip rap

ROCK GLUE Streambank Protection – Changwon City, Korea

Total installation time and cost less than concrete revetment.

Survived 150 year flood in 2014 while adjacent streambank protection systems washed away or experienced significant damage.



(a) During construction



(b) After construction

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(a) During 2014 flood



(b) After flood

ROCK GLUE Shoreline Protection – Jindo, KR 2011

Revetment alongside a beach was damaged by a typhoon in 2011. ROCK GLUE installed as part of restoration project.

In 2012, the coast was hit by super-strong typhoons *four* more times. While existing concrete dykes and embossing dikes at the coastline were destroyed, the area where ROCK GLUE was installed remained intact.

Before:



After:



After:



ROCK GLUE River Restoration



GwangRyu-chon project (2014)

- 1st riverbank restoration project in Korea
- Showed excellent performance against fast running water at heavy rain
- Good impression with natural landscape after 8 months



Daechong-chon project (2015)

- 1st small dam & riverbed restoration project
- Big impression with natural landscape



Daechong-chon 2 (2018)

- Riverbed restoration + Fishway



Danjang-chon (2019)

- Riverbed restoration + Fishway



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ROCK GLUE Submerged Breakwaters

- High porosity
 - ▶ Slower water speed
 - ▶ Reduces erosion
- Neutral to the environment
- Currently monitoring first installation



ROCK GLUE – Beyond Shoreline Protection



Q&A



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