Deltares

Enabling Delta Life

Eco-Engineering

Sustainable and cost-effective flood protection is vital to low-lying coastal and estuarine areas. At the same time, human use of these areas has become more intensive, resulting in less area for nature.
Dikes, and other traditional engineering structures, provide safety against flooding, but maintenance costs are high. Additionally, dikes do not keep up with sea level rise.
Traditional dikes provide little ecological or recreational values, thus the demand for multifunctional alternatives increases. Sand nourishments are a commonly applied form of soft-engineering, but due to their repetitiveness are likewise expensive.
In the Eco-Engineering projects of Deltares, coastal and river protection solutions are proposed in which natural engineering is combined with traditional engineering solutions.

Deltares aims to provide eco-friendly engineering solutions by two approaches:

1. Building with structures to create nature: Diverse Dikes
2. Building with nature to create structures: Bio-Builders

We create additional value to civil engineering projects in coastal systems while maintaining or enhancing safety levels:

- More biodiversity = more bio-productivity;
- More recreational value; and
- More flexible defense solutions that grow with sea level rise.

Diverse Dikes and Bio-Builders

Many of the world's coastlines are buffered with hard defense and harbour structures, such as dikes, dams, piers, docks and jetties. All of these structures serve as possible living areas for marine flora and fauna that are dependent of hard substrates for attachment, shelter and food. In the Netherlands, the Diverse Dike project has aimed to enrich these hard substrates by implementing improved dike designs; At the base of these designs lies the preservation of the original hydraulic dike function. The result is a larger biomass and diversity per surface unit, a more appealing landscape and a positive influence on the neighbouring water system.

In the development of new coastline defense and harbour structures, Deltares has researched, and subsequently advised a variety of natural engineering solutions. In these designs, a landscape is created using specific flora and fauna that reduces wave energy: bio-builders. These designs provide coastal protection and create valuable natural recreation areas.

Why is Eco-Engineering important?

The application of natural constructors has several great benefits. Creating a more natural environment, with a habitat for all kinds of organisms and possibilities for recreation, is the most obvious advantage.

An added advantage of bio-builders is their ability to adapt to their environment. Thus, as water levels vary due to climate change, the bio-builders can adapt to the variations and maintain their function of coastal protection. Furthermore, eco-engineers grow naturally, which means that construction costs can be limited, as are costs for maintenance and repair. By means of their activity, they play a crucial role in the cycle of all kinds of substances in the water: Some filter water so it becomes clearer, others assimilate substances so that these form a food source for other organisms. In this natural way, the water quality can be improved against much lower costs than what would be possible with chemical or mechanical purification.

Hard substrates are home to the most species diverse communities of all coastal systems in many world locations. Sea dikes and levees are a habitat to many, sometimes rare species and can contribute greatly to their dispersal. By enhancing the establishment possibilities for sea animals and plants like mussels, oysters, barnacles, algae and anemones, the ecological function of hard substrates can be significantly improved.

What is Eco-Engineering?

Eco-engineering is the use of engineering solutions, which improves traditional structures using natural resources to increase the structure functionality, or the use of natural materials (flora and fauna) to create structures.

In the last decade, management and development of wet nature values of dikes has been incorporated in Dutch policies, and several concepts for 'green' dikes and submerged reefs have been developed. To further improve the ecological value of hard substrates, the Dutch Ministry of Public Works and Watermanagement WINN-project 'Diverse Dike' was initiated in 2007.

The project aims for the design of ecologically diverse coastal defense structures, dikes, dams, piers and groynes, on a base of ecological functions. Safety against floods naturally plays a central role, but additionally the recreational value of the coastal environment can be improved as well. The concept has been developed in an intensive cooperation of ecologists and civil hydraulic engineers, and the designs are meant to be economically and practically feasible as part of existing or new designs for coastal infrastructure.

Rich Bank – water retaining substrate in the Delta. The local waterboard has equipped the bank structures of a section of the Eastern Scheldt with enriched, water retaining structures. This pilot covers a length of 1500 meters. Additionally, a test with enriched dike structures has been started on a dike section along the Western Scheldt (in cooperation with Heijmans and C-fix B.V.).

Xblocs – exposed dike on deep water. Besides the small tiles, a number of large Xblocs have been put in place, with the irregular texture of natural rocks. These blocks can be used for the construction of seawalls instead of the traditional cube-like blocks.

Saltmarshes grow with sea level change, therefore maintaining stability and safety

Bio-Builders are organisms that naturally occur in the relatively shallow waters along the coast and in inland waters, and that are capable of changing their environment in a way favourable to themselves. Such changes can be active, for example by excreting certain substances, but most changes are passive, simply by forming an obstacle that attenuates flow and protects the bed. Some examples include:

Oyster- and mussel reefs
Reefs of bivalves can function as stabilising or protecting agents because they reduce wave- and current intensity, and because of their ability to alter properties of the sediment.

Salt marshes, mangroves and osier-beds
Vegetated areas, such as salt marshes, mangroves and osier-beds, trap sediment by reducing flow velocities, by reducing hydrodynamic forces on the seabed and by improving consolidation of muddy soils by means of evaporation. Furthermore, they attenuate waves in front of coastal protection constructions, meaning that these require less height, enforcement and repair.

Tube-worms
A group that is often overlooked, but one that literally engineers: the worms, which contrary to the other eco-engineers, also occur in deeper water, build tubes of sand that protrude a few centimeters into the water. Some species even build entire reefs. Doing so, they increase sedimentation locally.

Reed floats
In areas that are initially not suitable for bottom vegetation, for instance due to the lack of shallow shores or large variations in water levels, floating devices often are applicable. Reeds, when grafted on willow matting, do not affect the sediment stability directly, but do attenuate small waves and thereby protect nearby banks, prevent resuspension of bed material and improve water clarity.

The future of Eco-Engineering

As a result of the pilot outcomes, the various designs of Diverse Dike are being improved constantly, and increasingly possibilities are being explored for implementation of the Diverse Dike concept in large-scale projects. Various Diverse Dike projects will be started in the Netherlands in the following years, and also outside of the Netherlands, projects for ecologically rich seawalls are being developed. The new Diverse Dikes will provide a pleasant environment for a large variety of species, through which the natural and recreational function of dikes can be greatly improved.

At present, living 'building blocks' are tested in the field, and full-scale pilots are initiated to explore their potential for both nature and safety, and to obtain experience with operational issues. Some examples in the Netherlands are the 'Zachte Afsluitdijk', the green wave-reduction dike at Werkendam and floating reed mats at Hoorn. Internationally, examples can be found in Louisiana, Singapore and Hong Kong.

Eco-engineers and Diverse Dike are a co-operation between Deltares and the Dutch Ministry of Public Works and Watermanagement Water INNovation (WINN) Programme.

WINN inspires, applies opportunities and experiments with water challenges. This way we work on solutions for future water tasks. Want to know more? www.rijkswaterstaat.nl/winn.

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Suggestions for further reading:

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