Please read this English translation of the article written by Pieter van den Brand for Waterforum April 2020 alongside the Dutch article to see the original layout and pictures.

Vision, utopia or grab bag of ideas?

Testing ground for levee experts

By Pieter van den Brand
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The transformation of the Hedwigepolder into tidal nature offers a versatile testing ground for flood defense experts. The Polder2C's-Living Lab will test the strength of the Scheldedijk and its use for emergency response across the spectrum. "We are going to give the levee a blow under extreme conditions."

In March, the excavators finally entered the Hedwigepolder to plow the landscape of fields and meadows with its tall poplars into new tidal nature. The objections to the plans to flood the polder were declared unfounded by the judge in 2018. After a delayed licensing procedure and, in the end, a further investigation into PFAS in the soil - with, as expected, no disturbing result - the Netherlands was able to live up to the agreements with Flanders to create additional nature for the deepened Scheldt estuary.

With its 465 hectares, the Hedwigepolder and the adjacent part of the Flemish Prosperpolder form the largest tidal area in Western Europe. After preparing the ground for construction, creeks and channels are dug. The water will soon have to flow through them to form mud flats and salt marshes. The soil that is extracted during the excavation work will be used as much as possible for the new levee, which should connect Flanders and Zeeland Flanders at the end of this year. When, according to plan, everything is completed at the end of 2024, part of the existing salt marshes and the Scheldedijk itself will be cleared, so that the tide can take its course.

Experiments
In the meantime, a unique opportunity arises: the redevelopment of the polders creates a very large test area on the Scheldedijk to conduct strength tests and practice emergency response. “We will be using the coming years intensively for all kinds of

experiments” say the beaming project leaders Patrik Peeters and Ludolph Wentholt of the Polder2Cs project. Peeters works at Flanders Hydraulics Research (WL), an expert organisation within the Flemish government, and Wentholt at STOWA in the Netherlands. The research project that started last year, is funded by the Interreg 2 Seas Programme (budget: 6.5 million euros, co-financed by the European Regional Development Fund). Knowledge sharing about the strength of flood defenses and crisis management is an important part of this programme, which is led by WL and STOWA. Rijkswaterstaat, the Ministry of Defense and Flemish, British and French water managers are also involved, in addition to engineering firms and knowledge institutions.

“We are going to realise research ideas that others can only dream of,” says Peeters, a researcher in Flood Protection at the WL. “The Scheldedijk is still in good condition. This is an incredible opportunity to get an idea of how durable such a levee system is. We will carry out wave overtopping and overflow tests and we will create breaching, to assess the levee’s behavior in extreme situations. Fortunately, we no longer experience major disasters, but this also means that our organisations do not have the required skills for a crisis situation. That makes this a unique experience. ”

Practice

Wentholt, a research coordinator in the field of Water Safety at STOWA for over 25 years, emphasises the wide scope of the testing ground. “We are not only able to calculate the probability of failure of the levee, but we can also simulate extremely realistic emergency situations and gain essential insights to keep the safety risks manageable in the event of flooding. We can determine whether we are "in control" or not. We know that there is a large gray area between theory and practice. The levee strengths calculated using models are difficult to relate to reality.” Peeters points out that levees are designed in a conservative way. “For safety purposes, we have built giant levees. That is very valuable, in all its meanings. The key question remains whether we can do even better than we have been used to, especially since we will be dealing with more water and higher water levels due to climate change. We hope to get some of the answers from this research project. We may be able to tolerate higher loads in the future, because our strength tests will provide us with more insight into the resilience of the current levee system and we may be able to improve this with smart

management and, if things do go wrong, we will be prepared with an experienced emergency organisation."

For the Netherlands, the question is also extremely topical, as there will be a reinforcement task of about 1100 kilometers of primary flood defense in the coming years. "Better insight into the strength of the system provides more knowledge in improving the lifespan of levees. That knowledge enables more targeted investment and management. Additional levee reinforcements may be needed later, "says Wentholt. "For the time being, however, these are assumptions that we will have to test in the Living Lab. "We are going to give the levee a blow under extreme conditions.", to see what the levee system still has to offer."

Growth of breaching

The infrastructural expertise on the Dutch side has been in previous projects with the IJkdijk, the artificially constructed levee in Groningen in 2012 was tested and monitored in a series of failure tests, and the Leendert de Boerspolder levee at Schiphol in 2015. This was the first real levee to be subjected to, in this case, a stability test. The toe of the peat levee was dug deeper and deeper, which caused the entire body of the levee eventually to slip and the polder to flood with water. Breach tests are also taking place on the Scheldedijk. The Flemings of Flanders Hydraulics Research are leading this. They gained experience at the 1994 Zwin experiment (the origin of the breach test in a tidal area on the Dutch-Belgian border) and at tests in Lillo, near Antwerp, in 2011 and upstream in Dendermonde in 2015.

Peeters is one of the specialists. "We want to test the existing breach models in practice. These models are suspected to be inaccurate. This is mainly because there are only a few experiments, and therefore measurement data. We hardly know how breaches occur and develop. A well-conducted breach test can provide useful information. "

Salt marshes

The earlier breach tests along the Scheldt have already given us many new insights, Peeters explains. "A breach seeks the path of least resistance and appears to go deep into a sandy material, only to become wider afterwards. With a breach that remains just

a few meters wide for a longer period of time, you can catch the inflowing water with pumps and a sewerage system in the underlying area. That means you don't have to panic immediately. During the previous tests we sometimes saw this happen. However, we want to gain a better understanding of what causes the limited width growth. In the Living Lab we study whether we can get this information confirmed or whether it may have been a matter of coincidence. We suspect that the presence of salt marshes influences this." The researchers will be satisfied in that respect. Several hundreds of meters of salt marshes must be excavated, otherwise they prevent the formation of new salt marshes and mud flats. "It is interesting that we will soon be able to investigate the growth process of a breach with and without the forelands on the river side of the levee."

Subtexts, photographs and textboxes:

Subtext p 1:
The Belgian-Dutch polder on the Scheldt which will become a 'playground' for levee experts in the coming years (photo: Vilda / Yves Adams).

Subtext foto p2:
Following this run-up simulator - here on the Waddenzeedijk south of Delfzijl - the Flemish will build an overflow generator that can run water over a levee for hours.

Text p2 foto:
Ludolph Wentholt (STOWA): "We are going to give the levee a blow under extreme conditions, to see what the levee system still has to offer."

Green box p 3:
Polder2Cs: arsenal of failure and management techniques
Polder2Cs deploys a wide range of resources, not only to practice levee breaches but also to protect the levee in crisis situations. The core of the strength tests themselves is simple: loading the levee body with water in waves and flowing water to cause erosion. Rijkswaterstaat has got three machines for this purpose.
The first device pumps an endless amount of water into the levee from above through a pipe system, to slowly raise the groundwater level. Levees do not collapse because

there is too much pressure on the waterfront. A levee collapses on one side - usually on the inside - under its own weight, because over time it becomes saturated with water, so that the sand and clay granules in the levee lose their grip. This situation is artificially brought about in the Living Lab by pumping water under the levee deep into the subsoil to increase the water pressure in the sand. The second type of machine pumps a wave of water onto the embankment of the levee. The run-up simulator hits the sand core of the levee and eventually pushes it aside. The third installation is the wave impact generator, which was developed several years ago by Deltares and Infram to test the strength of grass facings.
This device can simulate the most extreme wave impact on a levee.
The Flemings are going to build an overflow generator, in fact a huge basin on the river side of the levee at the same height as the crest, which is pumped full of water to allow water to flow over the levee for hours. This enables someone to measure the effect of overflow on the levee. Various existing techniques for emergency response are being investigated. In the Netherlands and Flanders, sandbags are the common solution for blocking high water. There are drawbacks, because emptying all those bags after the crisis period is a difficult and labor-intensive task. The British usually use large-sized flood signs. The ‘iron boards’ are tested extensively in the Living Lab. There are plenty of questions, because during storm Dennis, in February this year, the installed iron boards in England and Wales almost fell apart under the high water in the Severn.
Exercises with the "Bresdefender" are also on the programme. This floating pontoon of the Army, which has been weighted with water, can be sailed into a levee breach to support a weakened levee body.

Photo p 3:
Map of the "Living Lab" with the Scheldt on the right and on the north side the two locations (blue circles) where the breach tests will take place.

Photo p 3:
Patrik Peeters (WL): "We will realise research ideas that others only dream of."

Photo p 4:
In November 2015, for research purposes, a breach was made in the Scheldedijk in the river bend upstream of Dendermonde (photos: Flanders Hydraulics Research).

Green box p 4:

Flora and fauna under scrutiny: from fox hole to herb-rich plants

The unique position of the Living Lab Hedwige and Prosperpolder offers another interesting research object: the flora and fauna present on the levee. For example, the researchers want to examine the impact of fox holes on the levee. Not enough is known about the consequences of burrowing activities by foxes and other animals on the levee system. The question arises whether the safety risks are manageable and preventive measures are necessary or not. The business case is extremely interesting, because protecting levees against the digging spirit of foxes, badgers and beavers doubles the cost per stretching kilometer of levee to more than 1 million euros, as the calculations for levee reinforcement projects in Germany show. The British are particularly interested in the effects of badger setts on the levee body. In addition, in the Living Lab the relationship between levee design and management is examined and the diversity of grass and plant species and the strength of the facing.

Photo p 5:

In May 2012 a breach was made for research in the Scheldedijk near Lillo, north of Antwerp (photos: Flanders Hydraulics Research.)

Green box p 5:

Breaching a levee? Just blow it up!

The military involvement in the water safety testing ground in the Hedwige and Prosperpolder offers an extra dimension: practicing with explosives. The US Army Corps of Engineers (USACE) has already gained experience with this. In 2011, Mississippi waters were so high that USACE had to use the emergency overflow area at Bird's Point-New Madrid for temporary water storage to reduce water levels downstream and protect cities and towns in the states of Illinois and Kentucky. The breach in the Mississippi levee was made by blowing it up with explosives. This was partly successful, but a significant part of the levee was simply left standing. Meaning: the blown-up section of the levee fell back on its original location. The Americans want to further increase their knowledge and found a willing ear at the Dutch Ministry of Defense. Polder2Cs is a great opportunity to test breaching by using explosives. The military specifically wants to investigate the possibility of removing the top facing from the levee.

Questions include how many explosives are needed and how deep the explosive charges should be placed in the ground. The intention is to use explosions in such a way that only the levee is damaged and the surrounding area is affected as little as possible. The tests are carried out by the Regiment Genietroepen. This Defense unit has a training area in Reek for explosions underground.