Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
Polder2C's
European Regional Development Fund

D2.1.1 Pilot Breach Defender (BresDefender)

Photo: ministry of Defence, J.B. Strijk

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Adaptation to climate change

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D.2.1.1 Pilot Breach Defender (BresDefender)

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INTERREG Polder2C's project

The INTERREG Polder2C's is an international research project within the framework of the updated Sigmaplan for the river Schelde. The Hedwige-Prosperpolder will be transformed into tidal nature. Depoldering of Hedwige-Prosperpolder offers a unique testing ground, the Living Lab Hedwige-Prosperpolder, for flood defence and emergency response experts. In this environment current and innovative techniques, processes, methods and products can be tested for practical validation. Thirteen project partners, led by the Dutch Foundation of Applied Water Research (STOWA) and the Flemish Department of Mobility and Public Works (DMOW, Flanders Hydraulics Research), are working together. Together, they aim to improve the 2 Seas regions' capacity to adapt to the challenges caused by climate change.

Flood Defence

The rising sea level is a serious threat to the countries in 2 Seas region. How strong are our current flood defences? What is the impact of environmental elements such as the weather, the presence of vegetation or man-made objects on our flood defences? To answer these questions numerous destructive field tests are carried out in the Living Lab to validate flood defence practices. The project entails in situ testing, guidance on levee maintenance and validation of flood defence infrastructure.

Emergency Response

We aim to improve emergency response by developing the right tools for inspection of water defences, risk evaluation and solutions for flooding. If our water defences do not operate as designed, we must take the right measures to prevent flooding of valuable areas. The Hedwige-Prosperpolder Living Lab offers unique possibilities to exercise emergency management in the event of calamities under controlled but realistic circumstances. Activities that are part of the programme are levee surveillance and monitoring, emergency response exercises, breach initiation and the large European exercise.

Knowledge Infrastructure

We aim to develop a knowledge infrastructure through which existing and new to be developed knowledge will become available and accessible. A necessary success factor for any initiative to improve knowledge is to have its outcomes integrated in practices of a wider community. Knowledge Infrastructure focuses therefore on the consolidation of knowledge acquired in the Living Lab with a variety of activities. Accessibility of data in a user-friendly manner, educational activities in the field and incorporation of knowledge in educational curricula are considered key elements.

Field Station

How can we make sure that both experts in the field and the local public benefit from our project and the learnings about climate change, flood resilience, emergency response and the unique environment of the Hedwige-Prosperpolder? An important and unique way of reaching this goal is realising a Field Station at the project site. It will be used during and after the project for educational purposes, research and as a special meeting place for exclusive occasions.

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1 Introduction

One of the goals of Polder2C's emergency response working group is to do a test the principles of the innovative mobile barrier concept BresDefender.
The main goal is to evaluate the technical concept of the concept BresDefender as an innovative alternative for the current inventory of mobile barriers.
Within the BresDefender sub-project a technical design must be realized on the basis of the theoretical framework. This technical proof of concept consist of the development of a prototype BresDefender (scaled and full-scale) which will be used to validate and verify the theoretical concept through practical tests. It will answer the question: to what extent does the theoretical concept and prototype BresDefender (elaborated in the Dutch Defense Academy (NLDA in Dutch) /TU Delft PhD research represent reality.

A number of units of the Dutch military and civilians have been involved in this pilot. The project was led by PhD-candidate of NLDA /TU Delft Danny Janssen and executed by a team of the Military Engineering Centre of Expertise ('Kenniscentrum Genie' in Dutch), NLDA and 105 Multi Role Bridge, Dive & Construction Company.

This report starts put with a general description of the mechanism of the BresDefender in chapter 2. Chapter 3 with a discusses the outcome of the pilot and appraises the results. The report concludes with a number of recommendations.

2 Mechanism of the BresDefender

The BresDefender is an emergency response measure, which can be applied to increase the residual strength of a dike locally. Originally, a military pontoon, normally used by the military to construct temporal floating bridges. After some adjustments of the pontoon, it can be sunk in front of a weakened section of a dike, either reducing the discharge over or through a dike. Within the Polder2C's project, the prototype has been tested at three different scales: the laboratory scale, an intermediate scale at Flood Proof Holland (Delft) and at full scale in the Hedwige-Prosperpolder as part of the Living Lab. These tests have demonstrated the BresDefender's effectiveness as (waterborne) dike reinforcement and its potential for use in emergency response situations.

As part of the Polder 2C's project, a basin named Hedwigepool has been constructed within the Hedwige-Prosper polder, see Figure 19. The Hedwigepool was used to conduct real-scale experiments with the BresDefender. These experiments were generously supported by operational units of the Dutch military. Measuring 100 by 50 meters, the basin was specifically designed to simulate high water conditions in a river. This was achieved by filling the basin with water using pumps. The experiments conducted in the Hedwigepool provided valuable insights into the performance and effectiveness of the BresDefender in real-world flood scenarios.

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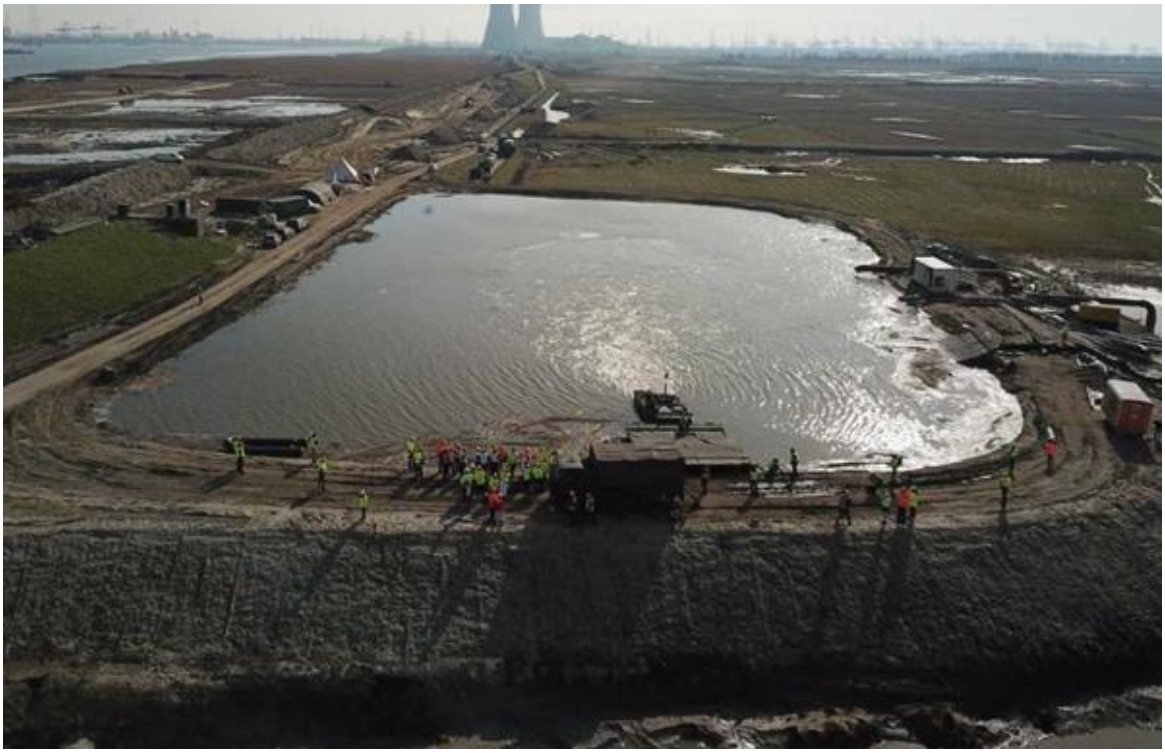

Figure 19 The Hedwigepool (test basin) in the Hedwigepolder, purposely built for emergency response research (mobile barriers and BresDefender), March 2022.

Using the BresDefender emergency response measure has several advantages over the application of traditional measures to stop a breach in its early stages:

- Application of the emergency measure is completely water borne
- It allows for multifunctional usage of military equipment
- It constitutes the only theoretical underpinned solution to avoid or arrest the breach initiation process in its early stages.

3 Experience/Appraisal

An effective deployment of the BresDefender in case of high-water emergencies, involves either or both of the following processes: i) arresting the breach growth process and ii) reducing the inflow(rate) of water into the levee, which ultimately would prevent macro-instability (mobilization of slip surfaces) of the levee.

3.1 *Stop the breach initiation process*

Experiments to stop the breach initiation process in its early stages were conducted in both Flood Proof Holland in Delft and the Hedwige-Prosper polder. The primary aim of the experiments was to test the applicability of a stiff structure positioned in front of a locally reduced crest level to minimize the total discharge through the breach. Additionally, the placement procedure of the pontoon was also tested in the Hedwige-Prosper polder.

Leakage discharge, flowing underneath the structure was collected within a box, and compared to the discharge when no emergency measure was applied. In Flood Proof Holland, the BresDefender was mimicked by a plywood plate.

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In the Hedwigepool, two different scenarios were tested. The first scenario involved an unmodified pontoon, and the second scenario involved a pontoon, wrapped by a flexible tarpaulin, see Figure 20. The second case, with the tarpaulin, reduced the discharge through the breach with more than 99 percent compared to the situation without an emergency measure. The measured discharge will still lead to erosion of dike core material; however, the erosion rate is a few orders of magnitude lower, compared to the situation without an emergency measure.

Figure 20 Deployment of the BresDefender emergency response method at an artificial breach in a Hedwigepool levee, March 2022.

3.2 *Reduce the groundwater inflow*

The effect of a seal covering the outer slope of the levee, on the development of the phreatic surface through the levee, in space and time has been researched in the TU Delft hydraulic laboratory, for a 2-dimensional experimental model case, and at Flood Proof Holland for a 3-dimensional experiment (Figure 21). Theory assumes that applying a stiff plate to obstruct the groundwater flow would increase the time required for the phreatic surface level to reach steady state conditions, meanwhile also decreasing the steady state level of the phreatic surface. Both aspects would lead to an increase of the factor of safety of the levee.

However, extended measurement series have demonstrated that the steady state phreatic surface level did not change when applying an emergency measure, contrary to the expectations. However, the time required to reach those steady-state phreatic conditions upon a sudden increase of water level, did increase. The leading parameter to achieve these conditions is the soil-structure interface, allowing leakage water to flow underneath the structure into the dike. Applying a seal as a preventive measure, before reaching steady state conditions, is expected to increase the time to steady state by 110-150% for the tested laboratory case. The 3D case showed a similar effect; however, little is known of the length of the seal in relation to its area of influence.

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Figure 21 Three-dimensional water inflow experiment at intermediate scale, Flood Proof Holland, TU Delft, spring 2022

4 Recommendations

The following recommendations for further research of the BresDefender, applied to reduce discharge through an initial breach, are advised:

1. Test the BresDefender emergency prototype in a fully developed flow case
2. Gain insight in the logistical processes which are occurring before the BresDefender can be applied
3. Adjust the pontoon, to increase its applicability
4. Automate the filling process
5. Improve the connection of the tarpaulin to the pontoon
6. Remove anchorage of the pontoon
7. Test the BresDefender with different conditions (wave conditions, on a rocky surface)
8. Study and practice the decision-making process (by water managers and civil administrators) during an actual crisis, leading up to deployment of the BresDefender.

The following recommendations for further research of a seal to reduce groundwater inflow, are advised:

1. Investigate the effect of seal length in relation to influence area
2. Investigate the most effective time to apply the intervention

Despite the need for more research on the dynamic and logistical processes involved in the application of the BresDefender in a real-world scenario, the BresDefender can be considered a promising tool to stop the breaching process in its early stages. As was mentioned by experts during an expert meeting on 8th of February 2023.

In the figure below a summary of that meeting is given as a visual.

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Besides technical aspects there are questions on decision making, logistics and a clear overview of the possibilities and do's and don'ts.

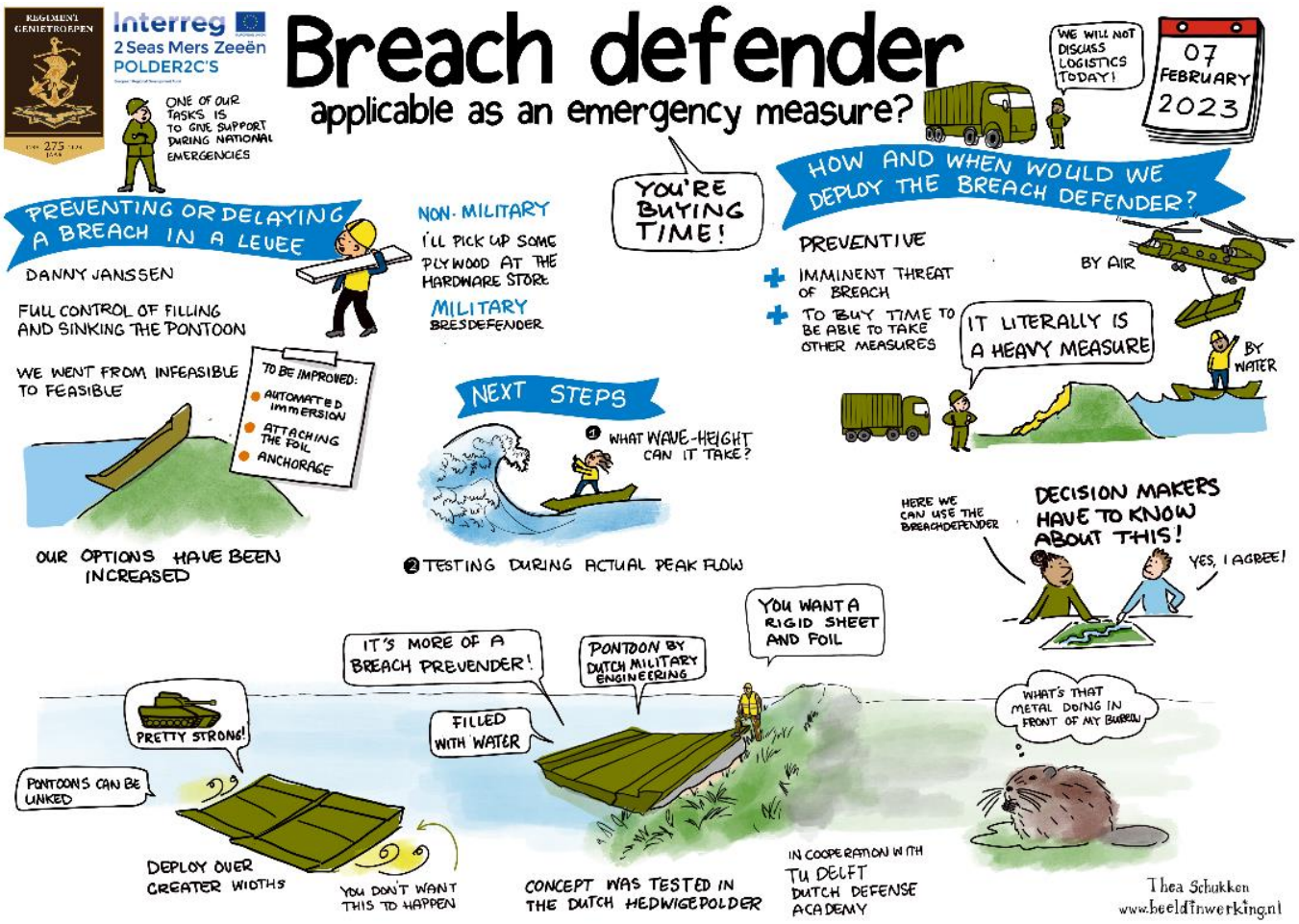

Figure 22 Visual summary of expert meeting BresDefender, 8th of February 2023

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