SIMPLE SCOUR ASSESSMENT FOR SEMI-CLOSED PORTS IN THE SOUTH BALTIC SEA

Piotr Szmytkiewicz, Institute of Hydro-Engineering, Polish Academy of Sciences, p.szmytkiewicz@ibwpan.gda.pl
Jan Schönhofer, Institute of Hydro-Engineering, Polish Academy of Sciences, j.schonhofer@ibwpan.gda.pl
Bartosz Zabłocki, Institute of Hydro-Engineering, Polish Academy of Sciences, b.zablocki@ibwpan.gda.pl
Michał Bojan, Institute of Hydro-Engineering, Polish Academy of Sciences, m.bojan@ibwpan.gda.pl
Krzysztof Piłczyński, Institute of Hydro-Engineering, Polish Academy of Sciences, k.pilczynski@ibwpan.gda.pl
Magdalena Stella-Bogusz, Institute of Hydro-Engineering, Polish Academy of Sciences, m.stella@ibwpan.gda.pl

INTRODUCTION

The formation of scour in the vicinity of breakwaters is not a new phenomenon. An example of the magnitude of such phenomena is, for example, the seabed scour that developed around the breakwater head in Mailiao Harbour in Taiwan (Lin et al. 2015). Within five years, the seabed in close proximity of the breakwater subsided from -22 m to -48 m. State of the art shows that such events occurr frequently around the world.

Scour formation around structures results from multiple causes. In general, based on the observations in nature and lab experiments, the mechanism of this phenomenon can be explained by the following factors (Myrhaug et al. 2004). They include increased near-bottom wave orbital velocities due to wave superposition, the foundation shape amplifying water flow velocity, wave breaking near the structure, additional pore pressures causing soil liquefaction, and turbulent water flow creating eddies. The seabed scouring process is non-linear and quasi-random, not fully explained by theoretical mechanics. Challenges persist in connecting hydrodynamics to sediment transport, leading to the reliance on simplified empirical guidelines from practical rules and laboratory observations (Sumer and Kirca 2022, Sui et al. 2023, Sumer and Fredsøe 2004).

MOTIVATION, AND AIM

There are generally two types of ports on the South Baltic Sea: those ports built at river mouths and the so-called medium-sized, semi-closed ports. An examples of this type of port is presented in Figure. 1. It is a medium-sized structure characterized by being enclosed on three sides by watertight walls. Water that enters the port due to extreme winds can only flow out between the heads of the breakwaters.

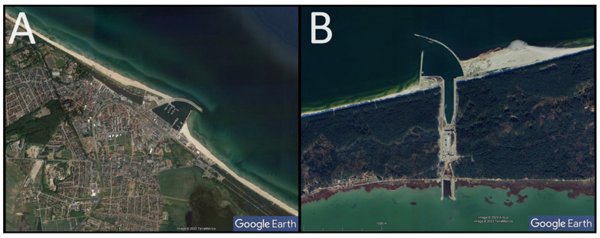

Figure 1 - A: Port of Władysławowo, B: Port of Przekop Mierzei, Poland. Examples of medium-sized semi-closed ports in the South Baltic Sea.

The motivation for undertaking this analysis was the occurrence of a large scour generated in the area around a newly constructed breakwater for the newly built Port Przekop Mierzei. The location of the scour and its scale are schematically presented in the figure 2. Within about a month, the seabed subsided from -7 m to -12 m, over an ellipse with dimensions of about 100 by 70 meters.

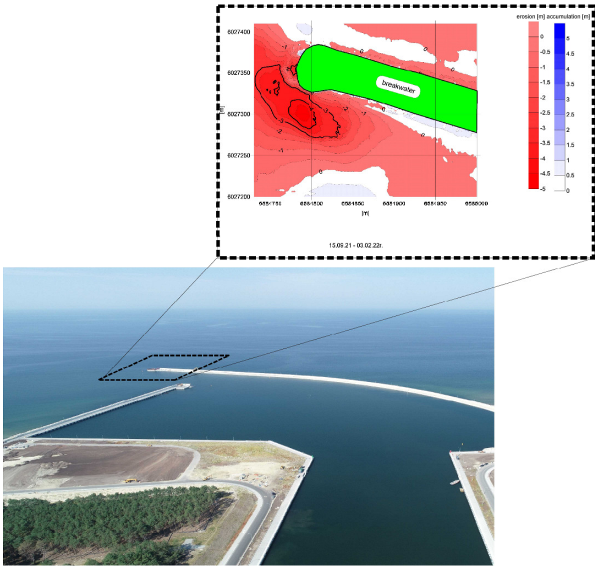

Figure 2 – Location of scour in the area of newly constructed Przekop Mierzei port, Poland. Within one month, due to the impact of extreme storms, the seabed deepened from approximately 7 meters to about 12 meters.

The aim of the study is to demonstrate a simple method for predicting the size of scour that will occur at the entrance to medium-sized, semi-closed ports as a function of storm surge inside the port and the port size.

METHODOLOGY

The analysis was conducted based on in-situ measurements, meteorological data from numerical hindcasts, and numerical simulations of waves, flows and sediment transport. In-situ measurements included bathymetric measurements at the location of scour formation in Port Przekop Mierzei carried out in a monthly routine during one year, six months of wave and current measurements (ADCP devices – Figure 3) at three sites in the identified scour area, and one year set of water level measurements. Meteorological data involved wind field data for the period when scour occurred and the period when ADCP measurements were carried out. Numerical simulations were performed using the Delft3D model. This software was utilized to reproduce the conditions that occurred during the scour formation.

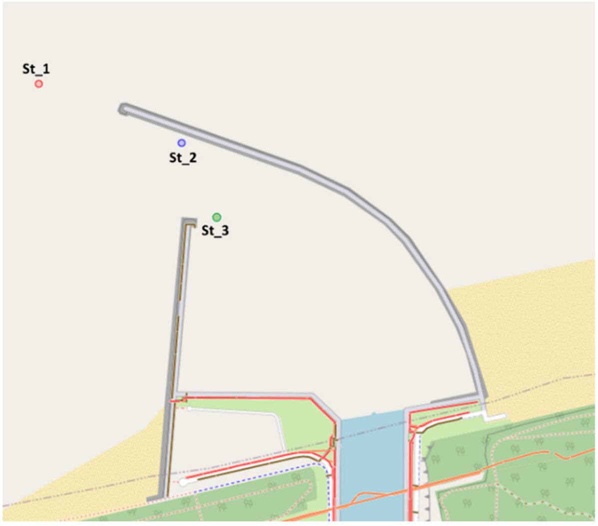

Figure 3 - Location of ADCP devices (St_1, St_2 and St_3) in the area of newly constructed Przekop Mierzei port, Poland.

CONCLUSIONS

The study reveals that the direct scenario leading to seabed scouring in Port Przekop Mierzei evolved as follows: the geographical location of Port Przekop Mierzei meant that the storms in January 2022 lasted long enough for the water level inside the port to be approximately 30 cm higher than the water level outside the port for several hours. Given that surface water movement was inward the port, at the seabed, the water movement was outward. As the water flowed out near the eastern breakwater, it led to the formation of the scour. Figure 4 illustrates a representative outcome of the calculated seabed evolution.

Based on the developed numerical model, it was examined whether the cause of scour formation is similar in other ports of this type. Using archival data, including dredging reports from the port of Władysławowo and meteorological statistics, instances when the water level inside the port was higher than outside. It was therefore demonstrated that the developed scenario of scour formation in medium-sized, semi-closed ports in the South Baltic Sea ports is similar.

The study demonstrated that, under specific geometrical conditions (port size) and wind exposure, which favor intrusions of water masses into the interior, the formation of scour in this manner will be possible.

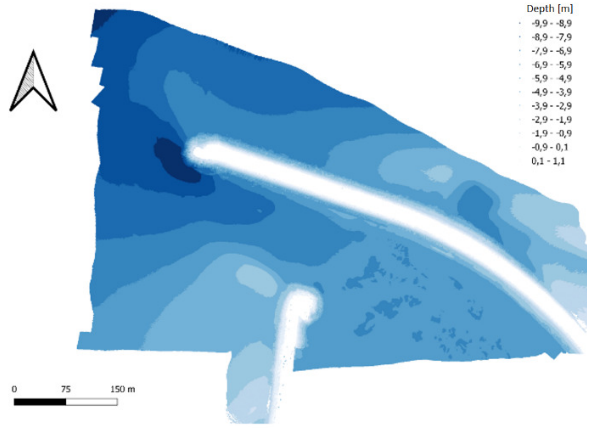

Figure 4 - An example of seabed evolution calculation for Port Przekop Mierzei for a scenario where water level inside the port was locally ca. 30 cm higher than outside.

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