Proceedings of the South Baltic Conference on
Dredged Materials in Dike Construction
Rostock, 10-12 April 2014
ISBN: 978-3-86009-409-9
www.dredgdikes.eu

THE PROJECT DREDGDIKES

Fokke Saathoff[1], Stefan Cantré[2]

[1,2] *Universität Rostock, Geotechnics and Coastal Engineering, Justus-von-Liebig-Weg 6, 18059 Rostock, fokke.saathoff@uni-rostock.de, stefan.cantre@uni-rostock.de*

Abstract. The project DredgDikes was initiated by the chair of Geotechnics and Coastal Engineering at the University of Rostock and by the chair of Geotechnics, Geology and Maritime Engineering at Gdansk University of Technology to investigate the use of dredged materials in combination with geosynthetics and coal combustion products (CCPs) in dike construction. The project is part-financed by the South Baltic Programme (EU INTERREG IVA). Five partners and 16 associated organisations from Germany, Poland, Denmark and Lithuania are involved in this project that officially started in September 2010 with a duration of 52 months. In the project two large-scale research dikes have been built, one in Gdansk and one in Rostock, which are under intensive investigation. Also, a joint pilot dike is being realised 30 km east of Rostock, with the use of ripened fine-grained dredged material in the dike cover. The project findings will be summarised in a guideline which will be published in English, German and Polish language to be distributed in the South Baltic Region.

Keywords: dredged material, dikes, geosynthetics, CCPs, pilot dike, full scale experiments, guideline

1. Background

Large amounts of sediments are removed every year from water bodies in maintenance and environmental dredging projects. In the eastern Baltic Sea large harbour projects will involve considerable dredging (ECODUMP 2014). The major amount of these dredged materials is relocated within the water bodies (Netzband et al. 1998; HELCOM 2011), however, if the amount of fines in the sediment would cause turbidity at the placing area or contaminations are involved, the materials have to be taken ashore which makes them waste materials after European regulations (Neumann and Henneberg 2014). Still, the materials are a valuable resource for agricultural use, landscaping or even as construction materials, particularly when they are not contaminated. Dredged materials that contain considerable amounts of fines and organic substance are usually dewatered and ripened before re-use. Experience shows, that some of the materials are well suited for the recultivation layers of landfill cappings, where high erosion resistance and extreme water retention capacities could be observed (Morscheck et al. 2014).

This resulted in the proposal to use this kind of dredged material as coastal dike cover material. The usual dike cover materials such as marsh clay (North Sea) and glacial marl (Baltic Sea) are becoming short and they have to be mined, usually in environmentally sensitive areas, while the dredged materials are readily available and need to be used beneficially. This is even a demand of the European Commission through the European Waste Framework Directive (Neumann and Henneberg 2014). Therefore, the cooperation project DredgDikes -part-financed by the European Union's South Baltic Programme- was initiated by the University of Rostock, Chair or Geotechnics and Coastal Engineering, and Gdansk University of Technology, Chair of Geotechnics, Geology and Maritime Engineering. Five partners and 16 associated organisations from Poland, Germany, Denmark, Latvia and Lithuania are involved in the project. To get different solutions for dredged materials application in dike construction implemented a recommendation guideline will be developed as final result. Information about the project can be found on www.dredgdikes.eu.

Fig. 1. Rostock research dike with filled polder 2, north view

2. The DredgDikes Idea

The main goal of the project DredgDikes is to get dredged materials implemented in dike construction. Therefore, possibilities to use different kinds of dredged materials in dike construction are investigated.

In the project, both a German and a Polish approach are considered to get dredged materials implemented in dike construction:

1. The very fine-grained, organic dredged sludges of Mecklenburg – West Pomerania coastal areas shall be used directly in the top layers of dikes. To level possible inhomogeneities of different materials and to allow for steeper slopes the integration with geosynthetic solutions, such as permanent erosion control and reinforcement systems, are investigated to convert the dredged materials into valuable resources for coastal protection. Additionally, dredged sands are used as dike core materials.
2. Fine grained dredged sands from Gdański region are usually not well suited for dike surfaces due to the high erosion potential. Also, there is a considerable surplus of ashes from coal combustion power plants in Gdansk. Therefore different sand-ash-composites are investigated to be used both in the dike core and as dike cover material.

Two large-scale field test dikes have been realized -one in Germany and one in Poland- to investigate the performance of the different approaches. Therefore extensive instrumentation has been installed and a considerable experimental program will be followed.

To show the reliability of best practice solutions, a pilot dike construction will be realized within an actual flood-protection project at the Körkwitzer Bach, 30 km east of Rostock. This investment will be used both for long-term monitoring and for dissemination purposes.

3. The Rostock DredgDikes Research Dike

The large-scale research dike in Rostock consists of two parallel dikes (west and east) which are connected with earth dams to form a three-polder system (Fig. 1). The polders can be filled with water separately for hydraulic loading. There are ten different dike cross-sections, all separated by mineral sealing material to prevent seepage water to spread between the sections. Most of the sections have been realised twice, on the eastern and the western dike respectively (Fig. 2).

The water level inside the polders can be regulated so that water flows over the crest-areas particularly lowered to realise overflow on defined parts of the slopes. The base of the construction is sealed by a geosynthetic clay liner for a defined hydraulic boundary condition. Five different dredged materials and four different geosynthetic solutions have been installed in the German test dike.

Three general types of cross-sections were realised: The dikes of polder 1 consist of a sand core covered with a layer of fine-grained dredged material with a thickness of 1.5 m on the outer (water side) slope and 1.0 m on the inner (land side) slope and a slope inclination of 1:2. In polder 2 slopes with an inclination of 1:3 are realised. The cross-sections consist of a sand core covered with a layer of fine-grained dredged material of 1.0 m thickness. Cross-section H in polder 3 is a homogenous dike made from material M3 (for the materials see Große and Saathoff, 2014).

To reduce shrinkage cracking in the dike cover layer, a geosynthetic reinforcement product was considered in surface parallel layers. Since the tensile stresses at crack development are assumed to be very low compared to the tensile strength of geosynthetic materials and the friction between soil and reinforcement material needs to be high even for very small displacements, a three-dimensional geosynthetic erosion control grid (Huesker Fortrac 3D) was used. Without reinforcement large cracks were expected that may reach the sand core. With reinforcement installed, a larger number of smaller cracks were expected, not exceeding the reinforcement.

To strengthen the surface of the greened slopes against erosion from wave attack or overflowing / overtopping events, a rolled erosion control product (Colbond Enkamat) was installed on three sections, covered by up to 5 cm of dredged material before greening. Without Rolled Erosion Control Product (RECP) considerable erosion may occur, particularly in bare or partly vegetated state, while with RECP the surface will be protected.

In the homogenous cross-sections of polder 3, innovative drainage solutions using a geosynthetic drainage composite (Colbond Enkadrain) shall control the phreatic line inside the dike core. Without installed drainage composite seepage water may soak the whole cross-section, coming out anywhere on the inner slope. With drainage composite, the seepage line should drop to the drainage layer and come out at a defined line along the slope or dike toe.

In spring 2012 the actual dike construction started. Due to the different slope inclinations and cross-sectional designs the construction technology was adjusted several times. A detailed description of the varied installation technologies and their performance is provided in Cantre and Saathoff (2013).

Since then a large variety of tests has been performed and more are planned for the year 2014. A selection of results has been published in these conference proceedings (Balachowski, Große and Saathoff, Nitschke et al., Olschewski et al., Ossowski et al.). Results about the geosynthetics used in the constructions can be found in Saathoff and Cantré (2014).

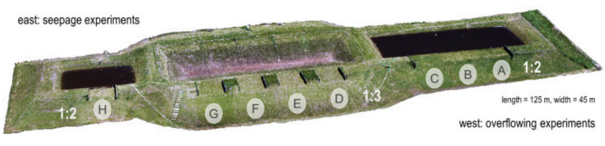

Fig. 2. Aerial view of the Rostock DredgDikes research dike (3D photo model: Naumann and Niemeyer)

4. The Polish DredgDikes Research Dike

The Polish research dike is made of different sand-ash composites. It was built at the bank of the Vistula in Trzcinisko, 20 km East of Gdansk. The dike core is made of a composite made of sand and bottom ash while the dike cover (thickness = 0.50 m) is partially made of a sand ash composite and partially a clay cover was applied. The choice of the material combination is based on intensive laboratory analyses at Gdansk University of Technology. There is a section of 5 m which in the middle of the dike where a 5 m wide sheet pile box was installed which exceeds the crest and in which seepage and overflowing tests can be performed. The dike has been equipped with moisture sensors and piezometers to investigate water infiltration into the dike body. For more information on the Polish research dike see Sikora and Ossowski (2013) and Ossowski et al. (2014).

5. The DredgDikes Pilot Dike

The dikes along the Körkwitzer Bach, a small river approximately 30 km North-East of Rostock, Germany, flowing into the Saaler Bodden, a coastal backwater, are dilapidated (Fig. 3). On a length of approximately 4.5 km the dikes are covered with trees and shrubbery and the crest height has declined due to ground settlements. In some sections the dike can hardly be recognized any more. The soil on both sides of the stream consists of up to 3 m peat over sand. The existing dikes are mainly made of peat which was dug out to build a drainage channel system on the adjacent agricultural land. Mineralisation effects lead to a further deformation of the peat dikes. There is also a pumping station draining a large area from both sides of the river into the Körkwitzer Bach.

A pre-plan for dike reconstruction along the stream had been prepared by a local planner estimating comparably high reconstruction costs due to the difficult ground, the risk of floods during the construction time because part of the adjacent areas are even below the sea water level, and the compensation measures with respect to trees and reed as well as the otters living in the area.

To reduce construction costs the use of alternative dike construction material was discussed which lead to the idea to include the measure in the DredgDikes project, defining a part of the reconstructed dike as pilot object using fine-grained dredged materials as dike cover layer. Therefore, a section of nearly 500 m length in the North-East corner of the Körkwitzer Bach was chosen, because between the stream and the village of Neuheide there is a polder directly connected to the pumping station which can be seen as a separately functioning area. Here the reconstruction of a small section made most sense with respect to an actual flood protection.

A standard cross-section was developed involving a construction road of 0.60 cm on top of a woven geotextile for reinforcement, which will be also the dike core. On top of the road / core a layer of 0.90 m of ripened fine-grained, organic dredged material is placed (Fig. 4). The dredged material used comes from the Hanseatic City of Rostock´s containment facility "Schnatermann". In summer 2013 the first 4000 m³ of dredged material was transported to the site to be stored ready for the construction.

On 27 November 2013 the construction of the test dike finally started. At first the drainage trench parallel to the dike was relocated because the reconstructed dike will partly rest on top of the old trench filled with soil from the old dike. Then the old dike was removed in sections and the construction road was built on top of the woven geotextile placed on the formation. Since the sandy gravel material used for the construction road has a low erosion resistance, part of the cover material was placed at the banks for erosion protection. Both the sand and dredged material was compacted using a sheep's foot roller compactor. The construction road was finished by 20 December 2013.

Works were resumed on 13 January after a particularly warm and wet period; however, high water and ice impeded further construction until the end of March (Fig. 5).

The pilot dike will be subject to long-term monitoring and investigations. The dike is being instrumented with a variety of sensors. Wires and aluminium strips were placed underneath the dike and between the sand core and the dredged material cover. In this way the thickness of the different layers can be determined using a cable detection device and the georadar method.

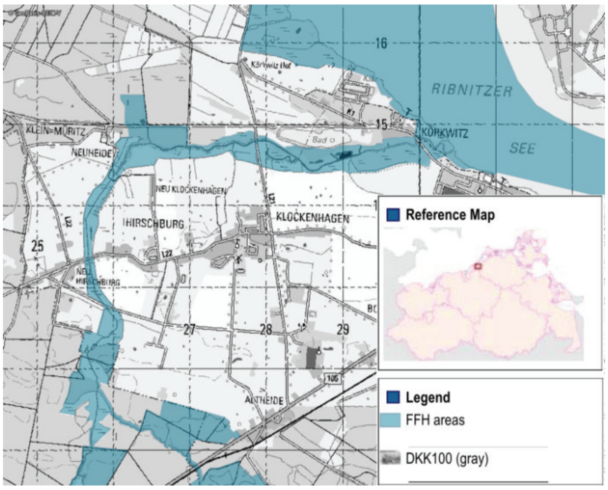

Fig. 3. Location of the Körkwitzer Bach and FFH areas along its banks (GeoBasis-DE/M-V).

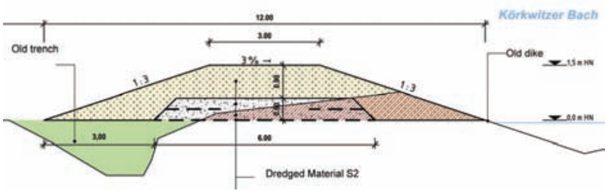

Fig. 4. Standard cross-section for the reconstruction of the dike at the Körkwitzer Bach (WastraPlan 2013)

Fig. 5. Frozen construction site 02-2014

Additionally, settlement gauges were installed on the surface to record the surface deformation.

To control the seepage through the dike body standpipes are being installed every 50 m from the crest into the sand core of the dike. Also, two sections will be equipped with tensiometers in the cover layer to receive information about the saturation of the dredged material. Together with water level gauges on both sides of the dike (water level of the Körkwitzer Bach and of the drainage trench on the western side) as well as precipitation and temperature sensors (both air and soil temperatures) the instrumentation generates data that can be used for future modelling of the system.

4. The Guideline

The DredgDikes project findings will be collected in a guideline on the use of dredged materials in dike construction in the South Baltic region. Therefore, also a study will be prepared on the possibilities to transfer the DredgDikes ideas to Denmark. The document will be produced in three languages: English, German and Polish. It will be provided as both print and digital versions. The print versions will be distributed to the important South Baltic stakeholders, such as political decision makers and public authorities dealing with the subjects. The digital version will be made available through the DredgDikes project website.

Acknowledgements

The authors would like to thank the South Baltic Programme of the EU for the co-financing, the Hanseatic City of Rostock for the dredged materials and place for the research dike, the Water and Soil Association together with the involved authorities for the successful planning of the pilot dike, Gdansk University of Technology and Steinbeis Innovation – Applied Landscape planning for the fruitful cooperation and all associated partners for their helpful contributions.

References

Balachowski, L. 2014. Stability of the Inner Slope of the Polish DredgDikes Research Dike at Stationary Flow, *Proceedings of the South Baltic Conference on Dredged Materials in Dike Construction,* Rostock, 10-11 April 2014, 105-110.

Cantré, S.; Saathoff, F. 2013. *Installation of fine-grained organic dredged materials in combination with geosynthetics in the German DredgDikes research dike facility*, Engineering Structures and Technologies 5(3): 93-102.

ECODUMP 2014. Application of ecosystem principles for the location and management of offshore dumping sites in SE Baltic Region [cited Mar 20 2014] Available online: <http://corpi.ku.lt/ecodump/>.

Große, A.-K.; Saathoff, F. 2014. Geotechnical characterisation of different fine-grained, organic dredged material batches from the Baltic Sea area – Peculiarities and adaptions, *Proceedings of the South Baltic Conference on Dredged Materials in Dike Construction,* Rostock, 10-11 April 2014, 19-30.

Morscheck, G.; Lemke, A.; Henneberg, M. 2014. Matured dredged material as restoration substrate in landfill surface sealing systems, *Proceedings of the South Baltic Conference on Dredged Materials in Dike Construction,* Rostock, 10-11 April 2014, 155-163.

Neumann, R.; Henneberg, M. 2014. Legal aspects for the reuse of dredged material and the application in dike construction, *Proceedings of the South Baltic Conference on Dredged Materials in Dike Construction,* Rostock, 10-11 April 2014, 189-194.

Netzband, A.; Christiansen, H; Maaß, B; Werner, G. 1998. Relocation of dredged material from Hamburg harbour in the River Elbe, *Water Science and Technology,* 37(6-7): 241-248.

Nitschke, E.; Cantré, S.; Saathoff, F. 2014. Fuss-scale Experiments at the German DredgDikes Research Dike, *Proceedings of the South Baltic Conference on Dredged Materials in Dike Construction,* Rostock, 10-11 April 2014, 53-59.

Olschewski, J.; Cantré, S.; Saathoff, F. 2014. Overflowing Tests on the Rostock DredgDikes Research Dike, *Proceedings of the South Baltic Conference on Dredged Materials in Dike Construction,* Rostock, 10-11 April 2014, 67-74.

Ossowski, R.; Sikora, Z.; Duszynski, R.; Sawicki, J. 2014. Investigation on water infiltration and water content changes in a large-scale experimental test dike, *Proceedings of the South Baltic Conference on Dredged Materials in Dike Construction,* Rostock, 10-11 April 2014, 47-51.

HELCOM 2011. Report on disposal of dredged materials at sea. [cited Oct 23 2013] Available online: <http://meeting.helcom.fi/web/monas>.

Saathoff, F.; Cantré, S. 2014. Geosynthetics and Dredged Materials in Dike Construction, *Proceedings of the 10th International Geosynthetics Conference*, Berlin, 21-25 Sept. 2014 (to be published).

Sikora, Z.; Ossowski, R. 2013. Geotechnical aspects of dike construction using ash-soil composites, *Procedia Engineering 57 (2013): 1029-1035*.