Geosynthetic Technologies in Hydraulics

Markus Wilke[1*]

[1]SOLMAX, International Business Manager, 6th of October, Egypt

Abstract. Geosynthetics are well known for substituting mineral filter layers for revetments. Apart from this established and common application they offer more specific and technical solutions for coastal and inland water structures. Typical hydraulic constructions like breakwaters and dikes can be strengthened and optimised using geotextiles or geosystems (bags, tubes, etc.). Till today the potential of geosynthetics for civil works in the marine environment is underestimated. Furthermore, the awareness by designers, construction companies and project owners for geotextile alternatives, saving time, money and enhancing the carbon footprint, can be substantially increased. Main reasons for the ignorance are missing design guidelines and a not existing general overview of their applicability in coastal zones and inland waters. This paper is intended as a first step towards a holistic approach to geosynthetics in hydraulics.

1 Literature overview of geosynthetics in hydraulics

In order to provide a better understanding of the current status of geosynthetics used in the marine environment a brief summary of the main hydraulic design guidelines including their references to geotextiles is given. In addition, the leading geosynthetic specific publications in relation to this field of application are listed.

1.1 Standard works for hydraulic engineering

The main two comprehensive technical guidelines applied globally for coastal and riverine structures are the Rock Manual [1] and the Coastal Engineering Manual (CEM) [2].
Both manuals don't provide design guidance on geosystems. They only refer to geotextiles used as filter layers in revetments and to fascine mattresses for underwater installation in challenging conditions (e.g. greater water depths or installations exposed to currents/waves).
Filter design principles mentioned in the Rock Manual are Giroud (1988) and La Fleur (1996). For further design assistance on geotextile filters, the Rock Manual is suggesting the German Code of Practice "Use of Geotextile Filters on Waterways" published by the Federal Waterway Engineering and Research Institute (Bundesanstalt für Wasserbau – BAW) from 1993 [3]. Meanwhile the document has been updated [4] but is only available in German.
The Coastal Engineering Manual recommends as geotextile filter criteria the work of Calhoun (1972). Furthermore, it advises to select the minimum geotextile physical properties according to Moffatt and Nichol (1983).

* Corresponding author: mwilke@solmax.com

In addition to the Rock Manual and the Coastal Engineering Manual several local recommendations and code of practices for specific hydraulic design aspects including recommendations on geotextile filter selection exist [5, 6, 7].

1.2 Geosynthetic guidelines for hydraulics

The most popular and citated work for this application area is the book of Krystian W. Pilarczyk "Geosynthetics and Geosystems in Hydraulic and Coastal Engineering" [8]. It is a collection of papers edited by Pilarczyk published in 2000. Due to the publication date most of the information have been outdated as meanwhile a lot of research has been carried out. Furthermore, a clear structure and comprehensive design guidance are missing. However, the book is still providing a good overview of potential applications.
Another standard work is the MarCom Report 113 "The Application of Geosynthetics in Waterfront Areas" published by the World Association for Waterborne Transport Infrastructure (Pianc) [9]. The report covers most aspects of geotextiles in the marine environment but is not giving detailed design assistance for all illustrated applications.
Concerning sand encapsulating geotextile elements, the up-to-date guideline including detailed design guidance is the book "Geosystems – Design Rules and Applications" [10]. Additional local guidelines [11] and papers [12] exist, containing relevant individual design aspects.

2 Geosynthetic applications in hydraulics

The geosynthetic applications for hydraulics are divided into two categories:

1. Standard applications and
2. Emerging applications.

A further differentiation is required between coastal and inland water applications, which is currently beyond the scope of this paper.

2.1 Standard applications

The following products are considered as standard solutions for geotextiles in the marine environment with guidelines available:

- Geotextile filter for revetments,
- Erosion control mats,
- Fabric formed concrete revetments,
- Geomembranes/geosynthetic clay liners for linings of canals/ponds,
- Geotextile bags,
- Geotextile tubes and
- Geotextile containers.

In comparison to the most traditional way of hydraulic construction, the use of rocks or rip-rap, even these methods are new and missing a comprehensive overall design guideline.

2.2 Emerging applications

There are numerous hydraulic niche applications, which originate from other geosynthetic application fields. Other products are specific to the field of hydraulics. In general, their use in the marine environment is increasing because of several advantages in comparison to

conventional alternatives. The following products are used on a more frequently basis in the hydraulic field:

- Silt curtains as suspension barriers,
- High strength wovens as basal reinforcement of breakwaters (and dikes),
- Geosynthetic clay liners as substitution of conventional clay layers for dikes and
- Geosynthetic Cementitious Composite Mats (GCCM) for erosion protection and linings.

For some of these applications guidelines have been recently developed. The state of Brandenburg in Germany has published a guideline for the application of geosynthetic clay liners in dikes [13] in 2016. Concerning basal reinforcement of breakwaters with geosynthetics, projects have been executed and scientifically documented [14].

3 Conclusions

The use of geotextiles for hydraulic engineering is increasing and becoming more common. Guidelines and design recommendations are existing for most of the applications. However, a holistic approach and design overview is missing. This paper is intended as a first step towards a structured and comprehensive summary of geosynthetic technologies in hydraulic engineering.

References

1. CIRIA, CUR, CETMEF, *The Rock Manual - The use of rock in hydraulic engineering (2nd edition)*, London, UK (2007)
2. US Army Corps of Engineers, *Coastal Engineering Manual*, Washington DC, USA (2003)
3. Federal Waterway Engineering and Research Institute (Bundesanstalt für Wasserbau – BAW), *Code of Practice – Use of Geotextile Filters on Waterways*, Karlsruhe, Germany (1993)
4. Bundesanstalt fuer Wasserbau, *BAW Merkblatt Anwendung von geotextilen Filtern an Wasserstrassen (MAG)*, Karlsruhe, Germany (2021) (only in German)
5. Federal Highway Administration (FHWA) - U.S. Department of Transportation, *Bridge Scour and Stream Instability Countermeasures – Experience, Selection, and Design Guidance, Third Edition*, Springfield, USA (2009)
6. Archive for Research and Technology on the North Sea and Baltic Coast, *Die Kueste – Empfehlungen fuer die Ausfuehrung von Kuestenschutzbauwerken durch den Ausschuss fuer Kuestenschutzbauwerke der Deutschen Gesellschaft fuer Geotechnik e.V. und der Hafentechnischen Gesellschaft e.V.*, Karlsruhe, Germany (2007)
7. M. Escarameira, *River and channel revetments – A design manual*, Thomas Telford, London, UK (1998)
8. K.W. Pilarczyk, *Geosynthetics and Geosystems in Hydraulic and Coastal Engineering*, Balkema, Rotterdam, The Netherlands (2000)
9. Pianc, *The Application of Geosynthetics in Waterfront Areas – Report N° 113*, Brussels, Belgium (2011)
10. A. Bezuijen, E.W. Vastenburg, *Geosystems – Design Rules and Applications*, CRC Press/Balkema, London, UK (2013)

11. Ministerium fuer Landwirtschaft, Umwelt und Verbraucherschutz Mecklenburg Vorpommern, *Uferlaengswerke – Geotextilwaelle*, CRC Press/Balkema, Rostock, Germany (2012)
12. T.W. Yee, *Dredging works and geotextile tube applications for construction of the longest sea-crossing bridge in Vietnam*, in Proceedings of Western Dredging Association and Texas A & M University Center for Dredging Studies, Dredging Summit and Expo 2015, Houston, USA (2015)
13. Landesamt fuer Umwelt Brandenburg, *Brandenburgische Richtlinie fuer die Anwendung Geosynthetischer Tondichtungsbahnen im Deichbau (BRAD 16)*, Potsdam, Germany (2016)
14. J. Rouck, K. van Doorslaer, J. Goemaere, H. Verhaeghe, *Geotechnical design of breakwaters in Ostend on very soft soil*, in Proceedings of the International Conference on Coastal Engineering, Shanghai, China (2010)