Introduction to bed, bank and shore protection

Cover:
“De machtige grijper, overwinnaar in den strijd tegen de zee” (The mighty grab, victor of the battle against the sea).
Johan Hendrik van Mastenbroek (1875 - 1945), Oil on canvas, Zuiderzeemuseum, Enkhuizen, The Netherlands.

Introduction to bed, bank and shore protection

Gerrit Jan Schiereck
updated by Henk Jan Verhagen

Delft Academic Press

Revised edition 2016

Published by Delft Academic Press / VSSD
Leeghwaterstraat 42, 2628 CA Delft, The Netherlands
tel. +31 15 27 82124
dap@vssd.nl
www.delftacademicpress.nl/f007.php

Printd edition: ISBN 97890-6562-4031
NUR 956

Keywords: shore protection.

A little learning is a dangerous thing;
Drink deep or taste not the Pierian spring.
Alexander Pope (1688-1744)

Preface

Every book is unique. 'This one is because of a combination of two things:

- the coverage of subjects from hydraulic, river and coastal engineering, normally treated in separate books
- the link between theoretical fluid mechanics and practical hydraulic engineering.

On the one side, many fine textbooks on fluid motion, wave hydrodynamics etc. are available, while on the other side one can find lots of manuals on hydraulic engineering topics. The link between theory and practice is seldom covered, making the use of manuals without understanding the backgrounds a "dangerous thing". Using a cookbook without having learned to cook is no guarantee for a tasty meal and distilling whisky without a thorough training is plainly dangerous. Manuals are often based on experience, either in coastal or river engineering, or they are focussing on hydraulic structures, like weirs and sluices. In this way, the overlap and analogy between the various subjects is missed, which is a pity, especially in nonstandard cases where insight into the processes is a must. This book tries to bridge the gap between theoretical hydrodynamics and designing protections. Imagination of what happens at an interface between soil and water is one of the keywords. However, this can only partly be derived from a textbook. Using one's eyes every time one is on a river bank, a bridge or a beach is also part of this process. In the same sense, a computer program never can replace experimental research completely and every student who wants to become a hydraulic engineer should spend some time doing experiments whenever there is a possibility. Anyway, the purpose of this book is to offer some know how, but even more important, some know why.

The painting on the cover represents three major elements in protection against water. The inset right under pictures the power of water, symbolised by Neptune who is enthousiastically trying to enter the gate while money and knowledge, symbolised by Mercury and Minerva, respectively, are the means to stop this. The painting itself depicts the granting of the right to establish an administrative body by the people of Rhineland, a polder area, by the count of Holland in 1255. People's participation is always a major issue in hydraulic engineering, as most projects serve a public goal. People's participation and money is not what this book offers, but I do hope that it will contribute to the knowledge to be able to make durable and sustainable protections.

Gerrit Jan Schiereck, Dordrecht, December 2000

Preface to the 2nd edition

The main reason to make a 2nd edition of this book was that we run out of copies. The basic setup of the book has not been changed. Also the fundamentals did not change in the last decade. Some new findings on turbulence have been added; the chapters on execution have been updated to the latest level of technology. Also a number of new examples from the last decade have been included. Finally the book is again in line with the latest standards. To indicate that this is a new version of the book a new cover has been designed. On the first cover an allegoric painting from the office of the waterboard of Rhineland was shown. For this edition I have selected a painting of Mastenbroek (1932) depicting the closure of the Afsluitdijk. A situation where the stability of the bed material was essential for the completion of the works. The painting expresses the strength of the grab, needed to combat the strength of the water.

Henk Jan Verhagen, Delft, July 2012

Acknowledgement
It is impossible to compile a book like this without the help of many people. In alphabetical order, we want to thank for their major or minor, but always important, contributions: Kees d' Angremond, Alice Beurze, Jeroen van den Bos, Henri Fontijn, Pieter van Gelder, Mark Lindo, Jelle Olthof, Jacques Oostveen, Kristian Pilarczyk, Hermine Schiereck, Jacques Schievink, Wijnand Tutuarima, Wim Venis, Arnold Verruijt, Dick de Wilde.

Contents

1 INTRODUCTION

Coastal protection along the Javanese coastline (photo Verhagen)

1.1 How to look at protections

1.1.1 Why and when

The interface of land and water has always played an important role in human activities; settlements are often located at coasts, river banks or deltas. When the interface consists of rock, erosion is usually negligible, but finer material can make protection necessary. In a natural situation, the interface moves freely with erosion and sedimentation. Nothing is actually wrong with erosion, unless certain interests are threatened. Erosion is somewhat like weed: as long as it does not harm any crop or other vegetation, no action is needed or even wanted. There should always be a balance between the effort to protect against erosion and the damage that would occur otherwise.

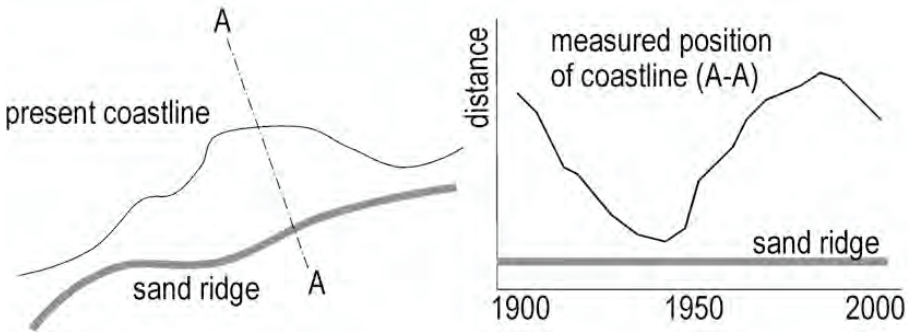

Figure 1-1 To protect or not to protect, that's the question

Figure 1-1 shows cyclic sedimentation and erosion of silt (with a period of many decades) seaward of a natural sand ridge. In a period of accretion people have started to use the new land for agricultural purposes. When erosion starts again, the question is whether the land should be protected and at what cost. Sea-defences are usually very costly and if the economic activities are only marginal, it can be wise to abandon the new land and consider the sand ridge as the basic coastline. If a complete city has emerged in the meantime, the decision will probably be otherwise. With an ever increasing population, the pressure on areas like these also increases. Still, it is good practice along a natural coast or bank to build only behind some set-back line. This set-back line should be related to the coastal or fluvial processes and the expected lifetime of the buildings. For example, a hotel has a lifetime of, say 50 years. It should then be built at a location where erosion will not threaten the building within 50 years, see Figure 1-2. So, in fact the unit for a set-back line is not meters but years! These matters are Coastal Zone Management issues and are beyond the scope of this book.

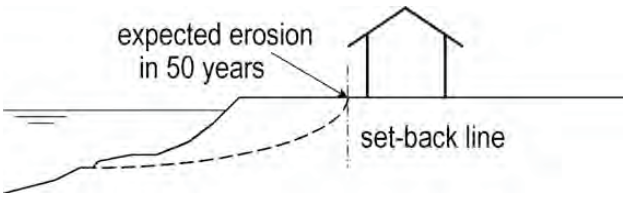

Figure 1-2 Building code in eroding area

Besides erosion as a natural phenomenon, nature can also offer protection. Coral reefs are excellent wave reductors. Vegetation often serves as protection: reed along river banks and mangrove trees along coasts and deltas reduce current velocities and waves and keep the sediment in place. Removal of these natural protections usually mark the beginning of a lot of erosion trouble and should therefore be avoided if possible. So, a first measure to fight erosion, should be the conservation of vegetation at the interface. Moreover, vegetation plays an important role in the ecosystems of banks. Chapter 12 deals with these aspects and with the possibilities of nature-friendly protections.

Finally, it should be kept in mind that, once a location is protected along a coast or riverbank that has eroded on a large scale, the protected part can induce extra erosion and in the end the whole coast or bank will have to be protected. So, look before you leap, should be the motto.

A lot of cases remain where protection is useful. Figure 1-3 gives some examples of bed, bank and shore protections. Along canals, rivers and estuaries, bank protection is often needed to withstand the loads caused by flow, waves or ships. Shore protection structures include seawalls, revetments, dikes and groynes. Bed protection is necessary where bottom erosion could endanger structures, like bridge piers, abutments, in- or outlet sluices or any other structures that let water pass through.

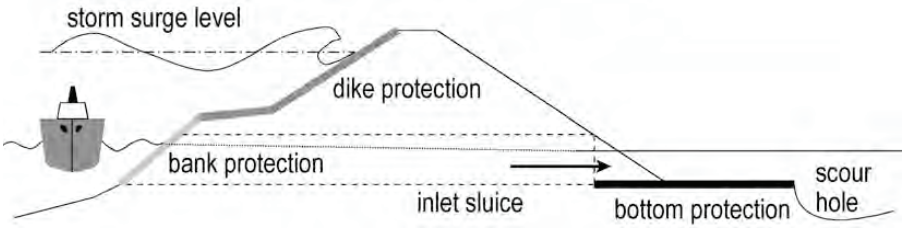

Figure 1-3 Examples of protection

1.1.2 Design

Protections of the interface of land or soil and water are mostly part of a larger project: e.g. a navigation channel, a sea defence system, an artificial island or a bridge. Therefore, the design of a protection should be tuned to the project as a

whole, as part of an integrated design process. In general it can be said that the resulting design should be *effective* and *efficient*. Effective means that the structure should be functional both for the user and the environment. This implies that the structure does what it is expected to do and is no threat for its environment. Efficient means that the costs of the (effective) structure should be as low as possible and that the construction period should not be longer than necessary.

A design that combines effectiveness and efficiency can be said to be "*value for money*" The intended value becomes manifest in the *terms of reference* (ToR) which contains the demands for a structure. This ToR has to be translated into concepts (possible solutions). Demands and concepts do not match one to one and a fit between the two is to be reached with trial and error. Promising concepts are engineered and compared. One comparison factor, of course, is costs. The designer's task to get value for money can be accomplished by compromising between four elements, see Figure 1-4.

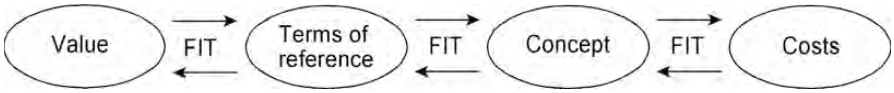

Figure 1-4 Value for money

The design process is of a cyclic nature because it is impossible to go directly from left to right in Figure 1-4. In the first phase, the designer works with a very general notion of the ToR and with some concepts in mind, based on his own or others' experiences. An integrated design process starts with a rough approach to all four elements in Figure 1-4, refining them in subsequent design phases. Effectivity can be evaluated in terms of functionality, environment and technology, while efficiency is expressed in terms of costs and construction although, of course, there are several overlaps and links between these aspects. They all play a role in each of the design phases, but the focus gradually shifts as indicated in Figure 1-5.

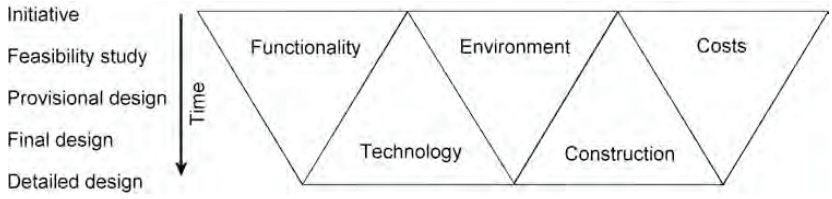

Figure 1-5 Focus during design process

Level of detail

In any project it is possible to discern various levels of detail. It is good to be aware of the level of detail one is working on and to keep an eye on the adjacent levels. An example of these levels (other divisions are, of course, possible):