Handbook of Scour and Cable Protection Methods – Advances in Tools and Modelling

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ABSTRACT

The Handbook of Scour and Cable Protection methods is the result of a multi-year research programme performed as a Joint Industry Project with the contribution of over 20 industrial partners. This project was initiated from the observation that no good and generically applicable design formulae and guidelines exist to protect offshore structures against scour. Instead, there are various existing methods and concepts that lack a sound basis for design. Different parties apply different solutions against scour around the support structure with varying degrees of success. To help decision makers select the most suitable and cost-effective scour protection method for each considered situation the Joint Industry Project Handbook Scour and Cable Protection Methods (JIP HaSPro) was initiated by Deltares. Apart from this research institute, the consortium consists of a certifying body (DNV), utilities (Ørsted, RWE, Vattenfall, Scottish Power, EnBW, Shell, Equinor, Ocean Winds), suppliers (SPT Offshore, Mibau Stema, Airgroup Industries, NoRock, SSCS), engineering firms (COWI, Kajima) and installation contractors (DEME Group, Boskalis, Van Oord, Jan de Nul, Tideway). The goal of this project is to develop a clear, generic and science-based comparison between different scour protection methods. In this project existing methods (based on loose rock) are optimized and new innovative scour mitigation methods are investigated (proof-of-concept) and made ready for offshore field tests. The resulting findings are presented in the Handbook of Scour and Cable Protections, which will be publicly available after finalization. All underlying technical reports and experimental data will be made publicly available as well to stimulate further development and collaboration on scour protection design within both academia and industry. Developers are actively encouraged to share field data of scour protection performance during the operational phase of wind farms to further validate and improve the present state-of-the-art of scour protection design for offshore support structures.

CONTENTS OF THE HANDBOOK

The Handbook of Scour and Cable Protection methods is, in general, aiming to provide guidance on scour protection design. Hence, the main focus of the document is on scour mitigation strategies and on how to design them for various types of offshore support structures. For offshore wind development, monopiles are selected in 60% of the time for their simplicity and adaptability. Although the primary principles discussed in the handbook apply to other foundation types as well, the main emphasis of the material presented in the handbook and the underlying research is on monopile foundations. The handbook is divided into four main parts consisting of ten technical chapters:

I. Scour development and mitigation strategies
   1. Scour prediction for offshore foundations
   2. Scour mitigation strategies
II. Scour protection methods – loose rock
   3. Design of loose rock scour protections
   4. Offshore rock gradings
   5. Rock scour protection installation
   6. Operation and maintenance of scour protections
III. Scour protection methods – Alternative
   7. Alternative scour protection systems
   8. Artificial vegetation
   9. Block, gabion and ballast-filled mattresses
IV. Ecological impact
   10. Nature-inclusive design

In the following, a brief description of the contents in each of the chapters is provided.

Chapter 1: Scour prediction for offshore foundations. This chapter provides a concise overview on theoretical background on scour and scour prediction methods, ranging from fast, semi-empirical methods like the Dynamic Scour Prediction Model by Deltares or the STEP model by HR Wallingford to high-resolution numerical modelling making use of CFD.

Chapter 2: Scour mitigation strategies. Scour mitigation strategies are introduced, presenting an overview of the various choices that a designer can make when considering the need to mitigate scour development. The various presented options provide a selection framework that can be used to decide upon the optimal protection strategy.

Chapter 3: Design of loose rock scour protections. This chapter provides an overview of how to design scour protections to fulfil three performance criteria: external stability (resistance against hydraulic loads), interface stability (sand-tightness) and flexibility (ability to cope with bed level changes at the edge of the protection). The design guidelines are based on an extensive physical model test database consisting of several hundreds of individual test results on multiple different scales (varying between 1:50 to 1:5). The test database was used to develop a scour protection deformation model where for each different scour protection deformation mechanism quantitative formulae are derived that can be used in the design of scour protections.

Chapter 4: Offshore rock gradings. Based on various mixed experiences with EN-13383 rock gradings, supplements and alterations to existing loose rock grading specifications will allow optimization and qualification of loose rock production and structure design. These supplements and alterations are given as new loose rock gradings and are named Offshore Sieved Gradings (OSG) and Offshore Weighted Gradings (OWG), with the most important difference that these gradings are closed compared to their EN-13383 counterparts and contain passage criteria. The OSG and OWG gradings align with EN-13383 coarse and light gradings.

Chapter 5: Rock scour protection installation. Rock scour protections of offshore wind farm foundations can be installed with different types of vessels. This chapter provides guidance on several types of equipment, installation sequence, possible interfaces to account for, evaluation of the installation and feasible installation accuracy and tolerances.

Chapter 6: Operation and maintenance of scour protections. Scour protections are typically designed as passive systems that do not require maintenance over the lifetime of the foundation as long as the design conditions are not exceeded. Thus, operation and maintenance typically relates to surveying and monitoring of the scour protection integrity and functionality. This chapter provides guidelines for scheduling of surveys, survey specification and execution and the evaluation of the surveyed data.

Chapter 7: Alternative scour protection systems. This chapter provides a high-level overview of several different alternative scour protection systems as opposed to the more conventional loose rock scour protection design. Generic information on the functioning of these systems, as well as their installation, operation and maintenance and decommissioning is provided. Several of these concepts are further investigated in more detail.

Chapter 8: Artificial vegetation. It is widely acknowledged that densely populated vegetation causes a reduction of near-bed flow velocities due to blockage and can thus also lead to reduced sediment transports and even deposition of sediments. Artificial vegetation attempts to imitate these properties. An artificial scour protection consists of a large number of individual fronds that are attached to an anchored frame of ballasted mattress forming a dense vegetation canopy. This chapter presents protection characteristics, potential failure mechanisms and design considerations.

Chapter 9: Block, gabion and ballast-filled mattresses. Currently, most alternative scour protection systems consist of weighted mattresses which are placed on the seabed to prevent scour around subsea structures or to protect vital infrastructure like pipelines and cables. This chapter provides an overview on their working principles, characteristics, potential failure mechanisms and design considerations.

Chapter 10: Nature-inclusive design. Offshore wind developments inevitably have significant impact on the environment, especially given the massively accelerated roll-out of offshore wind farms projected in the coming years. Recently, growing interest is shown in possible positive environmental impacts of wind farms, especially related to scour protections around offshore infrastructure foundations. These introduce a hard substrate to the sandy seabed areas, leading to the formation of new habitats that can affect the composition of marine species occupying this area. The growth of offshore wind through the associated introduction of hard substrates in the sandy seabed areas could, in some cases, lead to an opportunity of partial restoration of lost habitats. This chapter provides an overview of nature-inclusive design principles and concepts of which some have been tested in this Joint Industry Project, providing a basis for further development and field evaluations of ecological performance of scour protections.

CONCLUSIONS

The handbook of scour and cable protection methods is a product that is co-created with over 20 industry partners and it provides a set of generic guidelines to design a scour protection for offshore support structures. Besides establishing calculation methods, it also offers guidance on selecting a mitigation strategy, definitions on loose rock gradings to be requested at quarries, guidelines on installation, surveying and operation and maintenance of scour protections. Although the focus of this handbook is on loose rock as being one of the most well-established protection methods, alternative scour protection methods are investigated as well at a proof-of-concept level, making them ready for further development. The handbook further provides an overview of nature-inclusive design principles and concepts, paving the way to not only reducing environmental impact but providing an opportunity to strive for net-positive impact of offshore wind developments. The handbook will be publicly available for the entire industry to use. All underlying technical reports and experimental data collected within the project is made available as well to accelerate developments in scour protection design and to further enhance the collaboration between academia and the industry on this topic.