COMPLETED PROJECT CASE STUDY

EXPLORATION OF GROUTLESS ROCK ANCHORS TO SUPPORT AQUACULTURE INFRASTRUCTURE

PARTNERS

SCHOTTEL Marine Technologies, University of Dundee, Gael Force Group*

PROJECT LEADS

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**SCHOTTEL Marine Technologies acquired to the rights to the anchoring technology developed from the original project partners Sustainable Marine Energy (SME) and have concluded this project. SCHOTTEL Marine Technologies are continuing to develop, supply and deploy the groutless rock anchors discussed in this case study.*

BACKGROUND

Aquaculture operations rely heavily on stable infrastructure. Rock anchors are indispensable components within this industry, addressing critical challenges to the aquatic environment. These anchors play a pivotal role in securing aquaculture structures such as pens and barges against the constant forces of water currents, tides, and adverse weather conditions. By firmly anchoring these structures to the seabed or shoreline, rock anchors ensure operational stability, preventing drifting and displacement that could endanger both the livestock, the infrastructure itself, and others working or cohabiting in the marine environment.

Traditional rock anchors rely on grout or resin to secure them into place. However, integrating grouted rock anchors into aquaculture operations presents unique challenges. The marine environment subjects anchors to corrosion, necessitating the use of corrosion-resistant materials or protective coatings. Additionally, the design, installation and maintenance of rock anchors are time- and labour-intensive.

Despite these challenges, the benefits of rock anchors, including enhanced safety, stability, and operational efficiency, underscore their value as crucial tools to sustain and advance this sector of global food production.

Groutless technology has the potential to reduce the costs associated with traditional rock anchors, improve the efficiency of installation, minimise or eliminate corrosion, and decrease any risk of disruption or damage to the seabed.

This project originally brought together SCHOTTEL Marine Technologies and the University of Dundee, supported by the Sustainable Aquaculture Innovation Centre (SAIC). SCHOTTEL Marine Technologies provides rapidly deployable and environmentally focussed rock anchoring solutions for deployment within the marine renewables, aquaculture, and offshore sectors. The University of Dundee has world-leading subsea geotechnical engineering capabilities and undertook fundamental research to update SCHOTTEL Marine Technologies' Rock Anchor Geotechnical Model (RAGM). The study also included collaboration from Gael Force Group (GFG), which provided sample load regimes and site data that formed the basis of the design for the anchor.

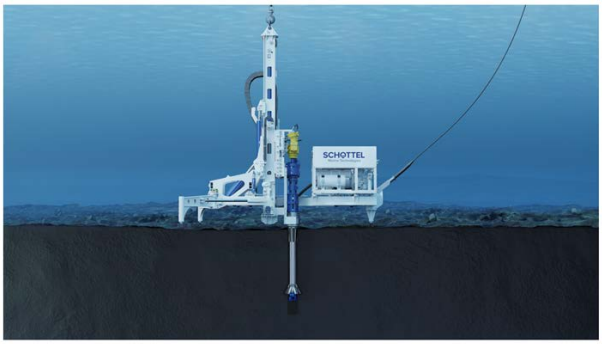

Image: SCHOTTEL Marine Technologies – Swift Anchor installation

> *Reliable and cost-effective anchoring is a critical component in every successful aquaculture project. Safeguarding the fish, as well as the local environment, is essential for responsible developers to ensure project viability and long-term profitability, no matter the size of project. Driven by the requirements to have rapidly deployable and robust anchoring systems to support these needs, SCHOTTEL Marine Technologies have developed solutions for offshore environments across a diverse range of challenging seabed conditions to offer more sustainable ways of anchoring aquaculture projects.*
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> ***Dr Nick Cresswell, Engineering Manager, SCHOTTEL Marine Technologies***

AIMS

The primary objective of this project was to critically test and improve the efficiency of SCHOTTEL Marine Technologies' existing rock anchor to meet the changing needs of the aquaculture sector. This objective included the improvement of SCHOTTEL Marine Technologies' Rock Anchor Geotechnical Model (RAGM) and exploring the design of an efficient anchor. The project aimed to understand the short- and long-term requirements and aspirations of the aquaculture market concerning anchor size and quantity.

By enabling the siting of farms in more energetic sites and deeper water, this project will help meet the industry and Scottish Government's shared long-term objectives of increasing aquaculture's contribution to the blue economy.

GROUTLESS ROCK ANCHORING

Groutless rock anchors, also known as mechanical anchors, have the potential to offer lower-cost and environmentally friendly alternatives to conventional grouted rock anchors. Unlike traditional rock anchors, which rely on grout or cement to secure them in place, groutless technology uses mechanical means to achieve anchorage.

During installation, these mechanical components cut an enlarged section of drilled hole at the base of the anchor, then expand into this area, creating an interlock and engaging with the surrounding rock, creating a secure attachment without the need for grouting. The use of groutless rock anchors can streamline the installation process and reduce the time and materials required compared to traditional grouted anchors.

Groutless rock anchors offer several advantages, particularly in efficiency of installation. A limited range of rock anchors have been used in the aquaculture sector to date. These are typically installed using hand-operated tools by technicians or divers. By comparison, SCHOTTEL Marine Technologies' current groutless rock anchoring technology is installed with a remotely-operated drilling rig deployed from a workboat or from the shore. This enables the groutless technology to be installed in deep water and energetic sites.Swift Anchor

Image: SCHOTTEL Marine Technologies – Swift Anchor

IMPROVEMENT OF EXISTING GROUTLESS TECHNOLOGY

SCHOTTEL Marine Technologies* installed the world's first subsea direct embedment groutless anchors in 2015 in the tidal waters of the Orkney Islands, using small multicat (multipurpose) vessels. It became clear that the technology had applications outside of marine energy, including the possibility of deploying the anchor in the aquaculture sector.

To ensure the technology will be usable for current and future aquaculture operations, this project has undertaken comprehensive modelling to prove the ability of the technology to be deployed in a variety of geological conditions. Specifically, the project team investigated six elements of the anchor system's behaviour:

1. Fatigue or cyclic loading effects on the anchor and system;
2. Performance of the anchor system under various inclinations of loading;
3. Effects of pre-tensioning the anchor concerning rock strength;
4. Effects of material choice;
5. Effects on performance in a variety of rock types (hardness, compressive and tensile strength);
6. Effects of fractures and discontinuity sets.

The University of Dundee undertook a critical evaluation of the SCHOTTEL Marine Technologies RAGM, which resulted in the implementation of numerous improvements to better represent the anchor and rock interaction. This assessment, based on simulations in analysis software, concluded that the prior methods for measuring pre-tension and the uplift failure mechanism were not accurate.

Following the critical assessment by the University of Dundee, simulations were performed to investigate the pre-tension effects on the anchor and the surrounding rock, as well as the likelihood that the applied load of the pen or cage would cause the anchor to be pulled out of the rock.

IMPACT

As the aquaculture sector grows and countries like Scotland aim to increase the employment opportunities and economic contributions of this sector, it remains vitally important to build long-lasting and future-proofed infrastructure. This project is a positive step in the development of sustainable and cost-effective rock anchoring systems.

The study met its primary objective of refining SCHOTTEL Marine Technologies' proprietary rock anchor geotechnical model for use in the design of anchors for aquaculture infrastructure. With the University of Dundee's critical assessment, SCHOTTEL Marine Technologies was able to develop a more robust geotechnical model. Additionally, the project highlighted areas of potential weaknesses in the anchor, including the discovery of multiple failure modes of uplift. As a result of this work, two new load conditions have been designed and presented.

The simulations performed during this project illustrated that anchor behaviour was more complex than expected. Although within the confines of this project it was not possible to derive an analytical solution encompassing the full range of rocks and rock mass structures, the results enabled a much improved understanding of anchor behaviour and rock fatigue, and highlighted areas for further research. The project formed a solid basis for the further development and validation testing of the RAGM by SCHOTTEL Marine

Technologies and has been key to underpinning their ongoing rock anchor certification with DNV.

ADDITIONAL INFORMATION

New anchoring technology for aquaculture takes a leap forward

The Scottish Government's Marine Directorate: A Technical Standard for Finfish Aquaculture