proserve
MARINE CONSTRUCTION ENGINEERS

PORTS & HARBOURS

CONCRETE MATTRESS SCOUR PROTECTION

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We think concrete function, durability & constructibility

Proserve have over 50 years' experience developing systems for marine construction, we understand the challenges of working with concrete underwater.

A company owned and run by professional engineers; we bring value to our global client base through collaborating with partners to develop construction methods and formwork solutions to enable reliable construction.

Martin Hawkswood
Director & Principal Engineer

OVER 50 YEARS OF PROVEN PERFORMANCE

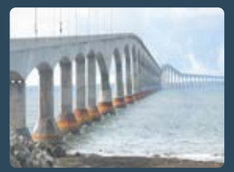
Partnership Expertise

Combining expertise with HUESKER for berth scour protection, Proserve provide customised solutions using HUESKER's uniquely woven Incomat formwork.

1966
Revetment Protection
River Arun
UK

1983
Scour Protection
Port of Belawan
Indonesia

1995
Hard Pad Foundations
Confederation Bridge
Canada

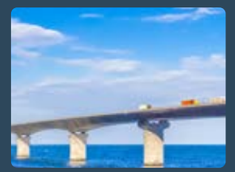


2010
Caisson Seals
Olmsted Dam Project
USA

2013
Caisson Foundations
MOSE Project
Venice

2016
Scour Protection
Puerto Quetzal
Guatemala

2017
Pier Foundations
La Reunion



2020
Scour Protection
Cruise Terminal
Port Canaveral, USA

CONTENTS

VESSEL INDUCED SCOUR

Scour actions can compromise the integrity of quay structures, erosion can be caused by:

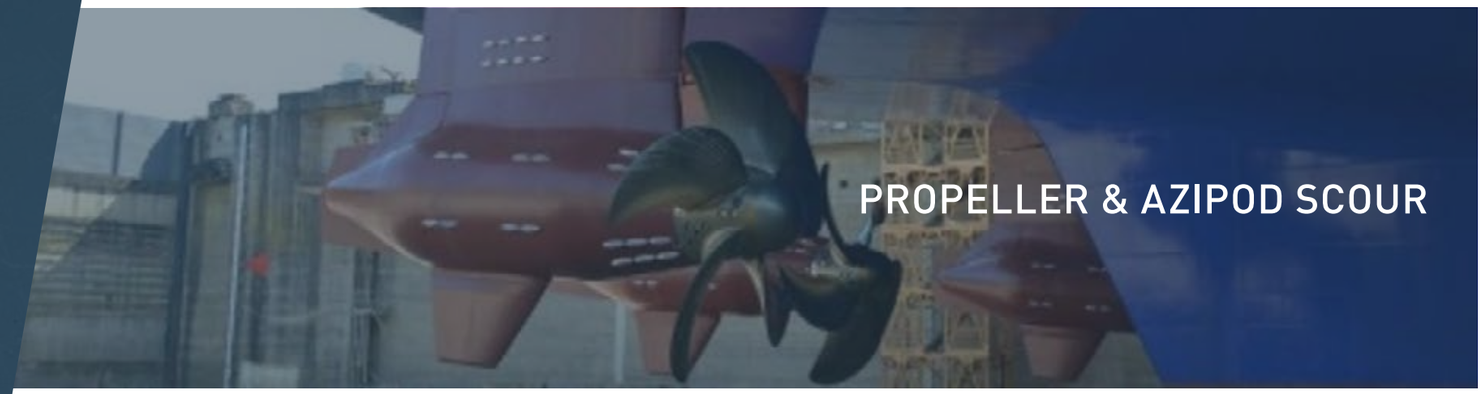
Propeller scour
Single and twin fixed propeller vessels, typically container ships and ferries. Can operate at low bed clearances and high powers.

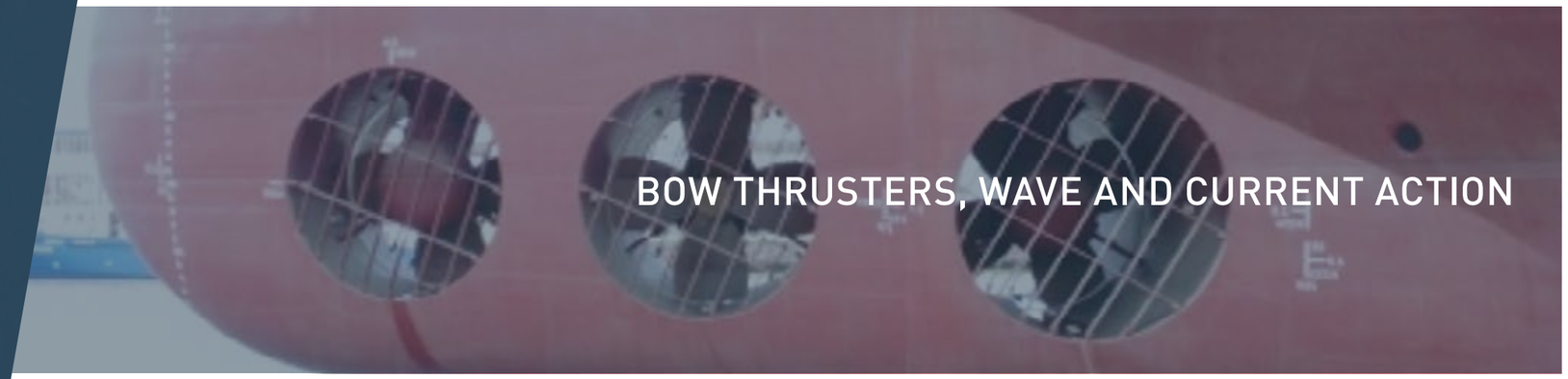
Azipod propulsion
Typically on cruise ships. Can be fixed and rotate on plan for high manoeuvrability with low bed clearances and high powers.

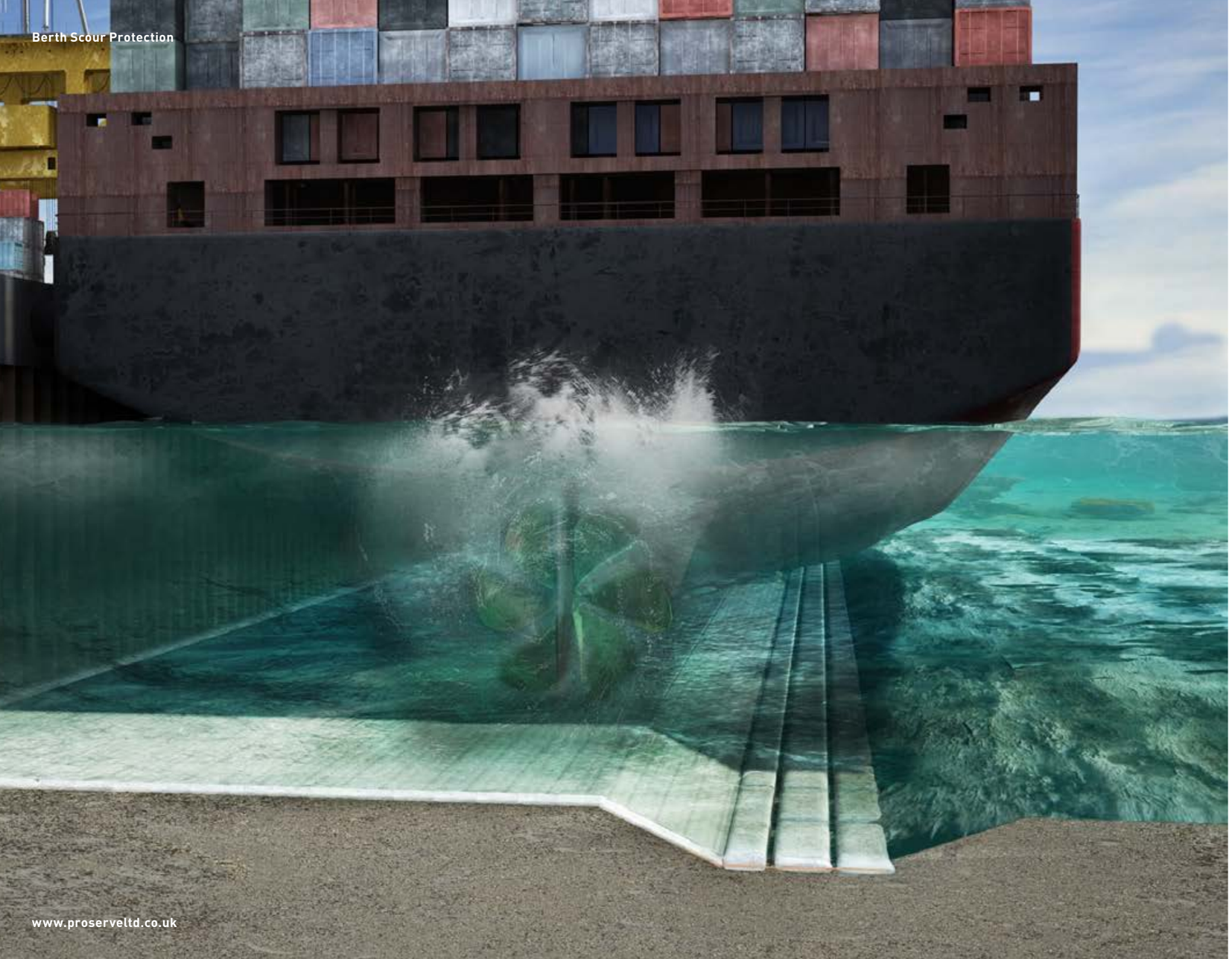
Bow and stern thrusters
Most vessels have a form of lateral thruster used with 100% power and directed at the berthing structure.

Wave and current actions
The principal environmental actions causing erosion.

RoRo Fast Ferry Jet scour
Water jets are common to catamaran and hydrofoil vessels. The high powered jets frequently create large scour holes when the vessel is berthing.







SOLUTION OVERVIEW

CONCRETE MATTRESS SYSTEM

The formwork produces an interlocking concrete apron over the protection area, offering unique performance:

Sealed Protection
The concrete slab effectively distributes hydrodynamic forces, requiring a protection that can be up to x7 thinner than traditional rock armour

High Performance
Resisting jet flow up to 12.5m/s

Proven
50 years of proven performance

Efficient
No marine plant needed, pumped filled from the quay by diver

Construction
Copes with high bed tolerances, needs less bed preparation than preformed mattresses

Secure
Does not suffer from rolling or sliding

System Explained
Installation

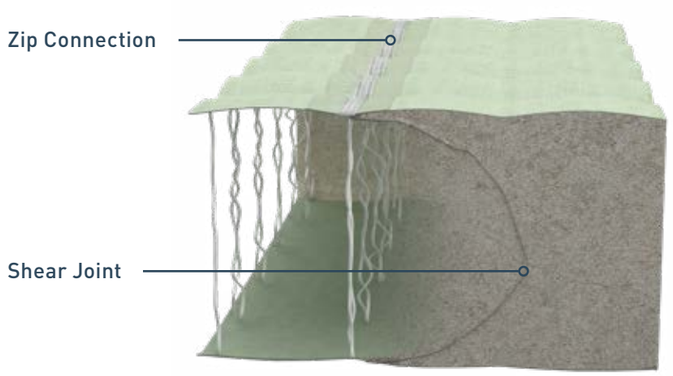
Filled in situ, the continuous protection is achieved by a top and bottom zip connection, creating the ball and socket shear joint interlocking the concreted panels.

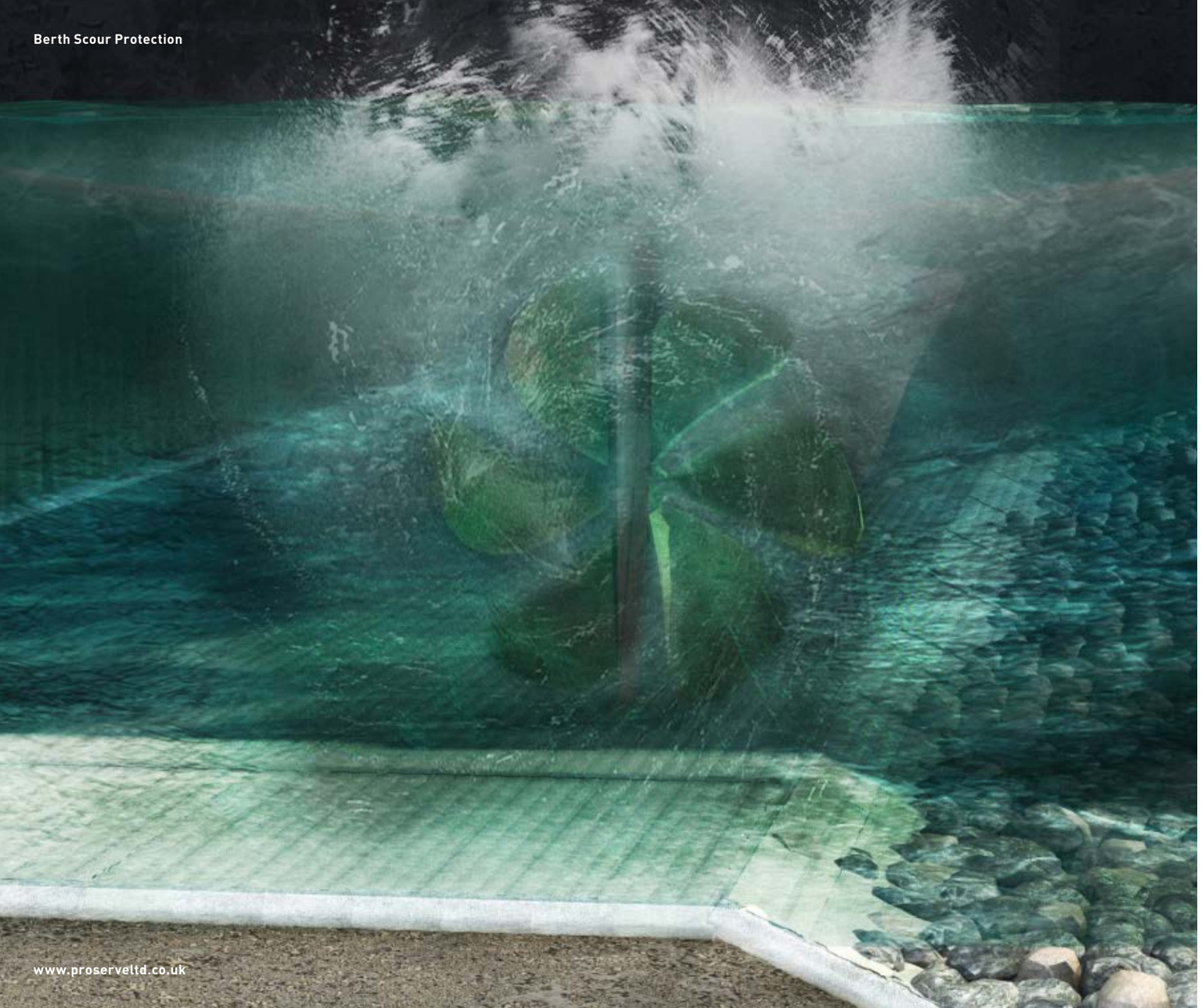
Pump Filling

- A fluid micro concrete mix is pumped into the formwork in tremie fashion.

- The porous formwork allows excess water in the mix to pass through the fabric, while entrapping the sand and cement particles, producing a highly durable concrete.

- The formwork provides protection from washout until the concrete sets.





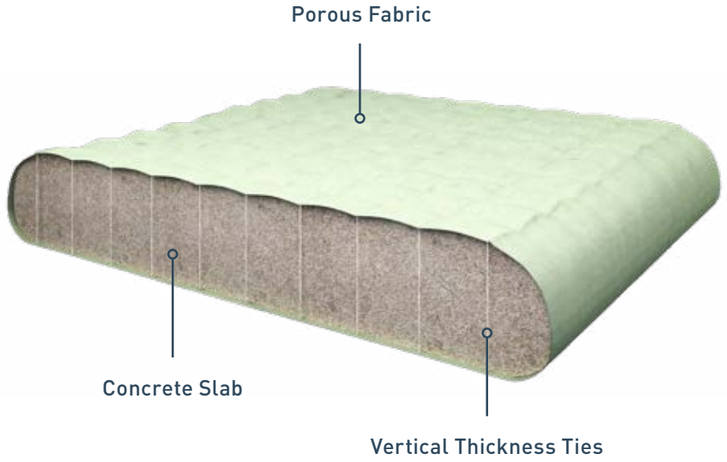
Formwork Technology
Concrete Mattress Solution

Advanced Formwork

HUESKER's Incomat has an unrivalled dimensional stability with the internal ties woven into the formwork, anchored between the top and bottom layers of fabric.

The market leading tie stability ensures:

- Incomat fills to the required thickness, eliminating high and low spots
- Low surface undulations reduce the required concrete to achieve the minimum thickness
- Smoother surface reduces the impact of hydrodynamic forces



OUR SERVICE

On every project we use our experience and expertise to identify the core project requirements and working constraints. This allows us to create solutions that are practical and improve the constructability of the project.

CONSULTATION

Establish the performance requirements of the concrete, assessing the working constraints and construction method options.

CONCEPT DESIGN

Definition of a practical in situ concrete solution that achieves the project requirements.

DESIGN EXPERTISE

Designs using in situ concrete mattress to form a 'sealed' protection layer.

CONSTRUCTION ENGINEERING

Defining the solution in detail, identifying risks, and incorporating mitigations into the construction method and formwork design.

CONSTRUCTION PREPARATION

Focused on managing the key construction risks, preparing detailed guidance, and training installation teams.

FABRICATION

Bespoke formwork, tailored by in-house technicians and quality approved by Engineers, delivered to site for reliable installation.

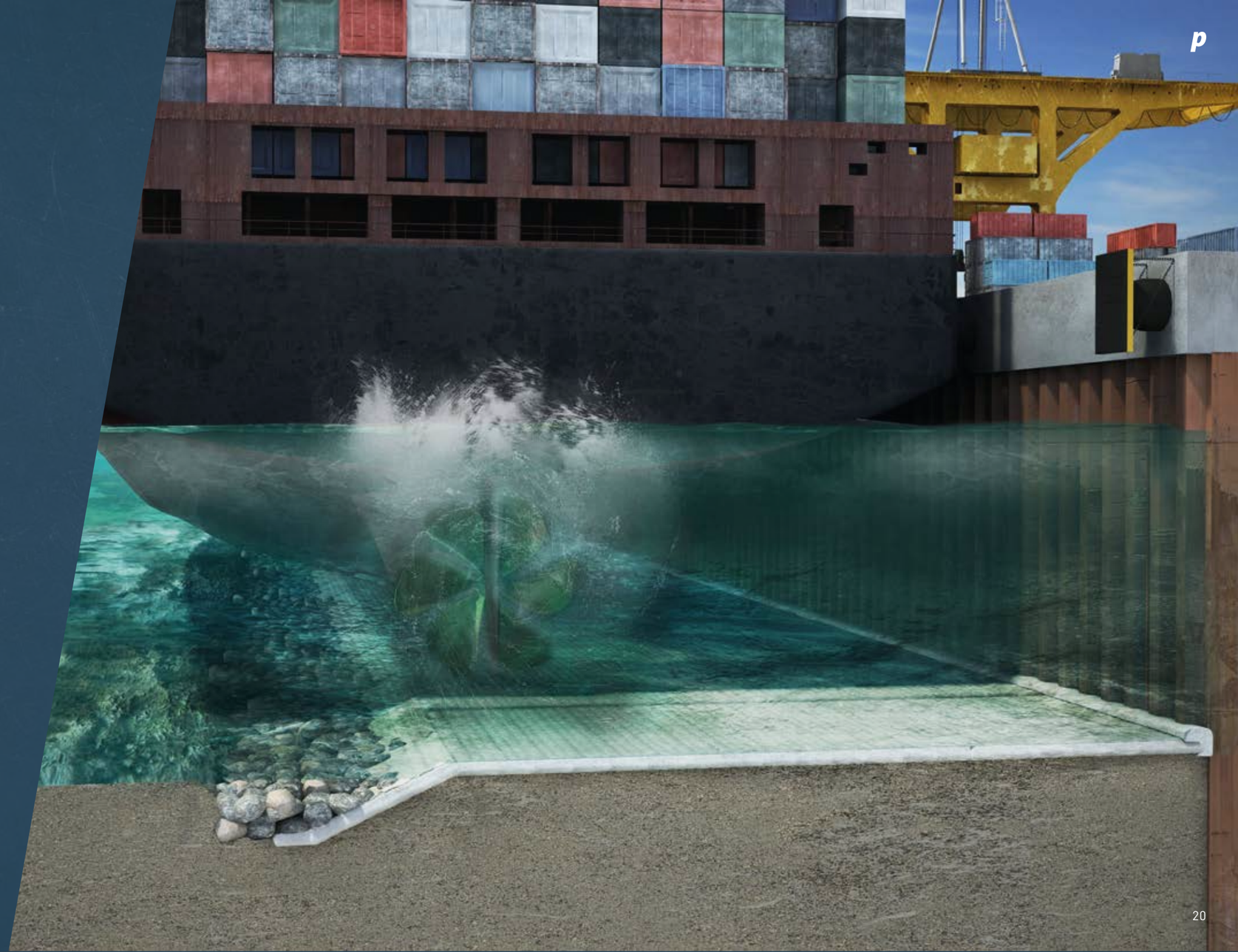
ON-SITE SUPPORT

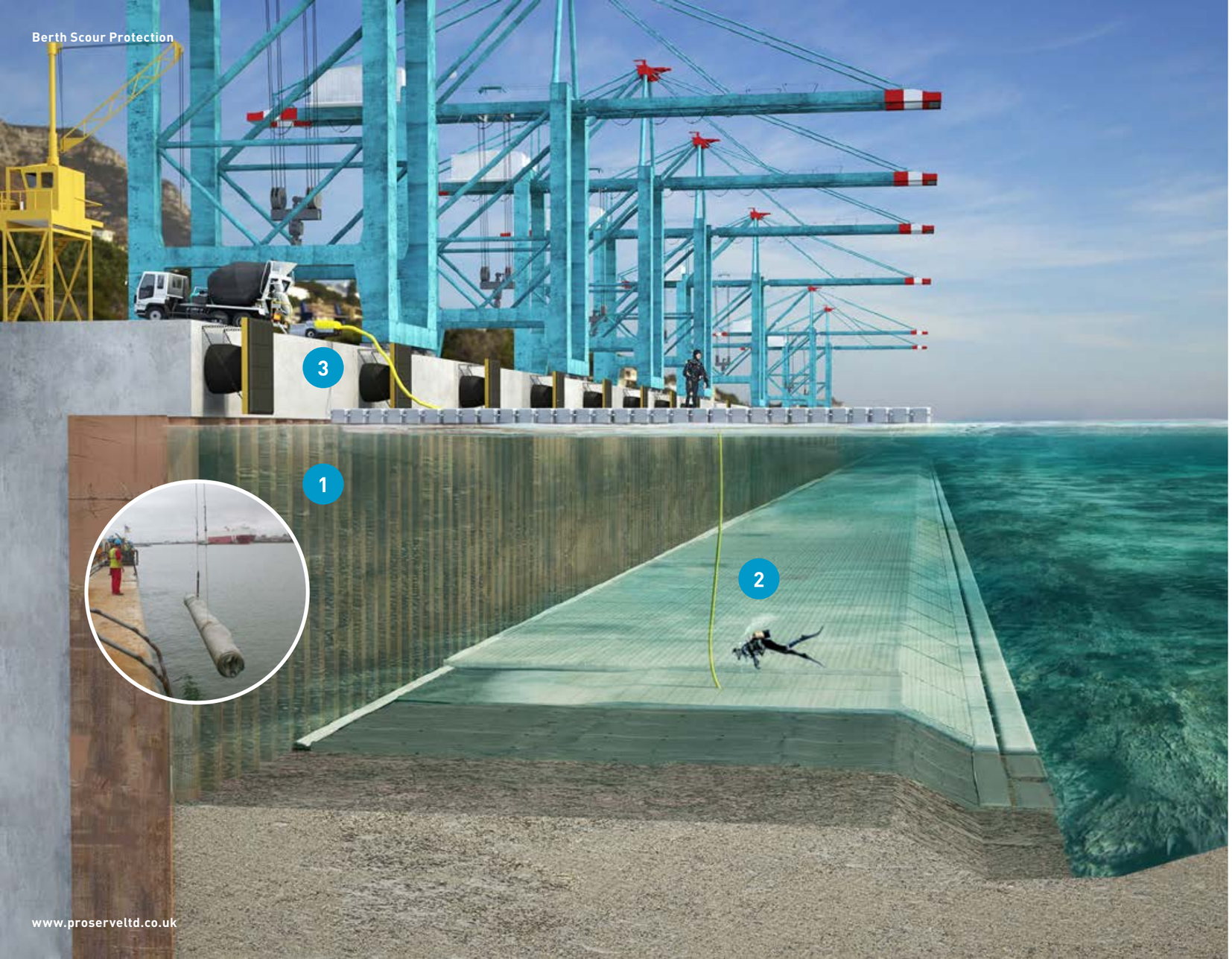
Expert Engineers provide specialist knowledge and support for successful construction throughout the project.

RELIABLE AND ROBUST CONCRETE

QUAY WALL SCOUR PROTECTION

Concrete mattress can deal with minimal vessel clearance & high propulsion velocity. The concrete slab is sealed against the quay wall and is protected at the edges by either a falling rock or concrete detail to eliminate underscour.





Installation

The concrete aprons are formed by divers rolling out formwork underwater which is pump filled from the quay side with a 2:1 sand cement micro concrete mix 35N/mm² strength. The fluid concrete is protected against wash out during curing by the formwork.

1. Formwork lowered and rolled out by diver
2. Zipped to neighbouring panel
3. Pump filled in tremie fashion from surface

The typical installation rates per day per dive team are 125-300m2 depending upon working conditions

Advantages

Sealed Protection

- With effective joints creating a continuous concrete apron, the system is sealed against flow caused by propeller action.
- Sealed systems can withstand much greater hydrodynamic forces than open systems.

New Berths

- Reduced dredging and quay wall height

Berth Deepening

- Increased depth capacity from existing quay structure

PILED QUAY WALL SCOUR PROTECTION

Concrete mattress provides unique revetment protection from both vessel and wave action. A sealed concrete apron to the wall and around the piles, prefabricated porosity holes enable effective wave run down, ensuring the slab is not lifted. The system has 50 years of proven usage on revetments.

Installation

The formwork is tailored to suit each structure ensuring a continuous slab and controlled installation is achieved. The system can be installed underneath the deck due to the fabric being lightweight to handle prior to filling.

Precise dredging is not required due to the system being filled in situ, adjusting to the tolerances of the revetment, with excess material provided to ensure the panel does not come up short.

1. Formwork panels are pulled out to each bay
2. Restrained at wall and fixed around piles
3. Zipped to neighbouring panels by diver
4. Pump filled in tremie fashion from surface

Advantages

- Can be installed under the deck ensuring works on above the deck can continue
- Much thinner protection than multiple layers of rock armour
- Expensive marine plant not required for installation
- Better joints and performance than preformed mattress protections
- Copes effectively with revetment tolerances

CASE STUDIES

A selection of berth scour protection case studies, detailing the various construction methods used.

Martin Hawkswood
Director & Principal Engineer

JETTY RE-CONSTRUCTION

Port Au Prince, Haiti

Engineer: Technitel
Contractor: GLF USA
Protection Area: 19,600m²
Year: 2014-2015

A new piled jetty for container vessels was constructed at Port au Prince following the 2010 earthquake, when the old jetty slipped into the sea due to liquefaction. The jetty deck was formed in precast and in situ RC construction, and is 500 m long, with a dredge level of 11.5 m. Constructed using steel shell piles driven by land-based piling plant to save on marine piling costs, the jetty berth and slope was dredged and excavated from land by long reach excavators working around the piles.

Solution

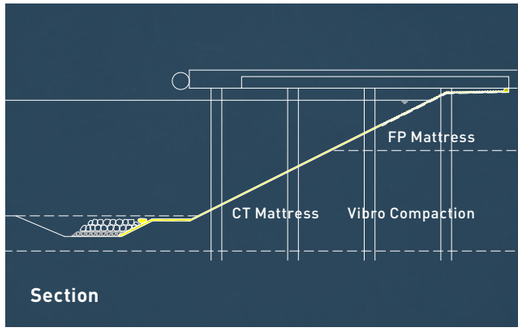
In situ concrete mattress was selected for its performance on slopes, ease of installation with the limited access underneath the deck and providing a more cost competitive solution than rock. Proserve have provided support to the designer, Technital, and to the contractor, GLF on site for the installation of the system using divers.

Installation

The formwork was fixed around piles, zipped to neighbouring panels, typically taking some 2 hours. The pump filling of micro concrete starts from the bottom of the slope and progresses upwards. Divers fix the pump hose end into mattress filler sleeves and fill in tremie-filling fashion. Mattress filling typically takes 6-8 hours.

JETTY RE-CONSTRUCTION

Port Au Prince, Haiti



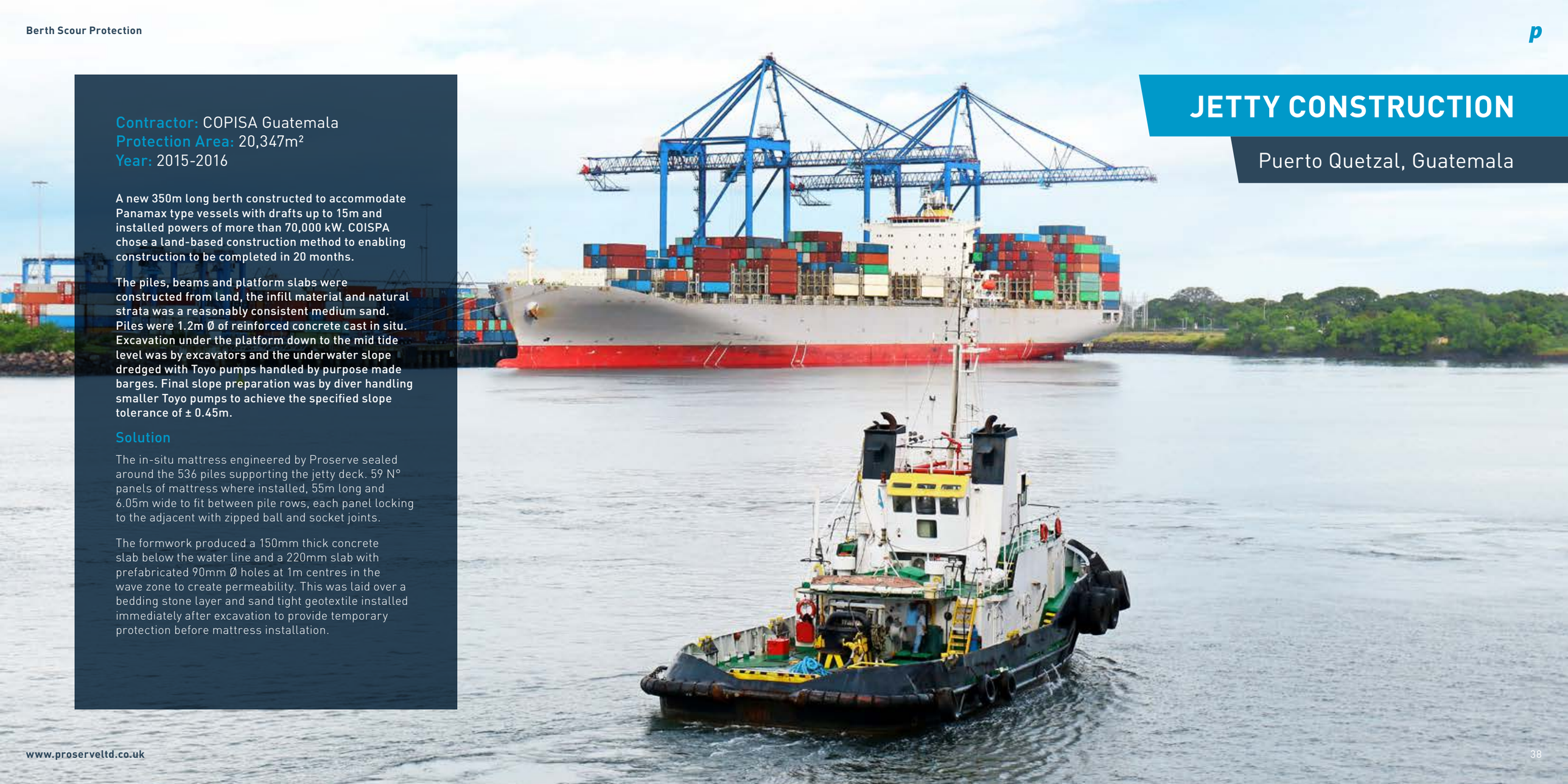
Section

Pile Seal Connection

Concrete Set

JETTY CONSTRUCTION

Puerto Quetzal, Guatemala



Contractor: COPISA Guatemala
Protection Area: 20,347m²
Year: 2015-2016

A new 350m long berth constructed to accommodate Panamax type vessels with drafts up to 15m and installed powers of more than 70,000 kW. COISPA chose a land-based construction method to enabling construction to be completed in 20 months.

The piles, beams and platform slabs were constructed from land, the infill material and natural strata was a reasonably consistent medium sand. Piles were 1.2m Ø of reinforced concrete cast in situ. Excavation under the platform down to the mid tide level was by excavators and the underwater slope dredged with Toyo pumps handled by purpose made barges. Final slope preparation was by diver handling smaller Toyo pumps to achieve the specified slope tolerance of ± 0.45m.

Solution

The in-situ mattress engineered by Proserve sealed around the 536 piles supporting the jetty deck. 59 N° panels of mattress where installed, 55m long and 6.05m wide to fit between pile rows, each panel locking to the adjacent with zipped ball and socket joints.

The formwork produced a 150mm thick concrete slab below the water line and a 220mm slab with prefabricated 90mm Ø holes at 1m centres in the wave zone to create permeability. This was laid over a bedding stone layer and sand tight geotextile installed immediately after excavation to provide temporary protection before mattress installation.


Pump Filled From Deck


Formwork laid


Sand tight seal

JETTY CONSTRUCTION

Puerto Quetzal, Guatemala

CRUISE TERMINAL

Port Canaveral, Florida, USA

Engineer: Mott MacDonald
Contractor: RUSH Marine
Protection Area: 11,983m²
Year: 2019-2020

The expansion at Port Canaveral included the construction of a new berth to accommodate the 180,000-ton LNG powered cruise ships by Carnival Cruise Lines. The new cruise vessel powered by x3 enormous azipod thrusters with 20MW power each and 360-degree rotation enabling the ship to perform on-the-spot manoeuvres without assistance from tugboats. The powerful propulsion combined with minimal hull clearance required thin and robust scour protection to protect the important wall superstructure from under scour.

Solution

A range of mattress types and thicknesses 200mm – 600mm (8" to 24") were specified to different protection zones by the Designer Mott MacDonald to overcome the propeller suction forces from the low clearance and the high berthing power of the cruise vessels.

Installation

Working in collaboration with Rush Marine & Viking diving, developing a suitable concrete mix & providing onsite training and support for the system. The mattress panels were installed in challenging conditions, with zero visibility, and powerful cruise ships passing multiple times per day. The 'zip flap' system was used that allowed mattress to be installed 1-by-1 with no unfilled mattress needing to be fabric left in the water overnight vulnerable to propeller wash.

CRUISE TERMINAL

Port Canaveral, Florida, USA

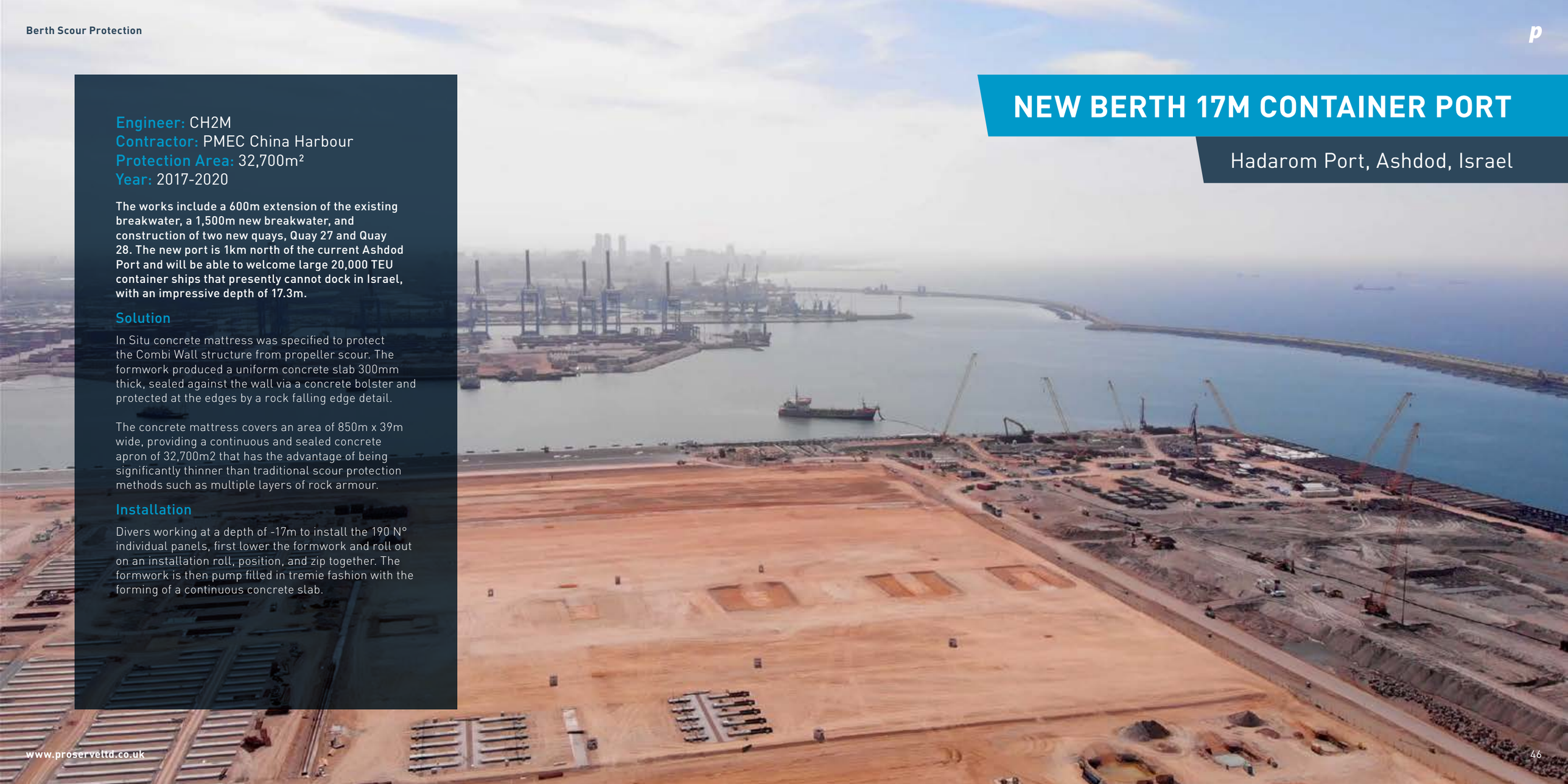

Azipod Propulsion


Zip flap


Working around vessels

NEW BERTH 17M CONTAINER PORT

Hadarom Port, Ashdod, Israel



Engineer: CH2M
Contractor: PMEC China Harbour
Protection Area: 32,700m²
Year: 2017-2020

The works include a 600m extension of the existing breakwater, a 1,500m new breakwater, and construction of two new quays, Quay 27 and Quay 28. The new port is 1km north of the current Ashdod Port and will be able to welcome large 20,000 TEU container ships that presently cannot dock in Israel, with an impressive depth of 17.3m.

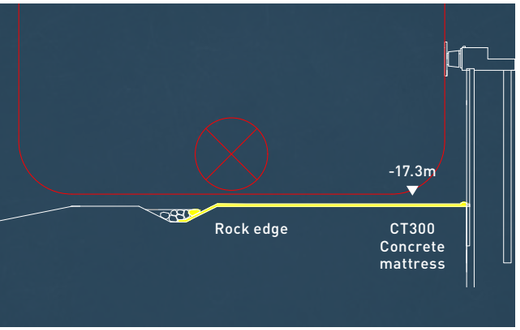
Solution

In Situ concrete mattress was specified to protect the Combi Wall structure from propeller scour. The formwork produced a uniform concrete slab 300mm thick, sealed against the wall via a concrete bolster and protected at the edges by a rock falling edge detail.

The concrete mattress covers an area of 850m x 39m wide, providing a continuous and sealed concrete apron of 32,700m2 that has the advantage of being significantly thinner than traditional scour protection methods such as multiple layers of rock armour.

Installation

Divers working at a depth of -17m to install the 190 N° individual panels, first lower the formwork and roll out on an installation roll, position, and zip together. The formwork is then pump filled in tremie fashion with the forming of a continuous concrete slab.




Land trial


Hose Management

NEW BERTH 17M CONTAINER PORT

Hadarom Port, Ashdod, Israel

BERTH DEEPENING

Red Sea Gateway Terminal, Saudi Arabia

Consultant: Technital
Contractor: Saudi Archirodon
Protection Area: 7,500m2
Year: 2017

In 2017, the newest of three container terminals at Jeddah Port, Saudi Arabia, underwent a major expansion project increasing its capacity from 1.8 million TEU to 2.5 million TEU.

The quay comprises 330 m of existing construction, previously protected with traditional rock armour, and 45 m of new construction. To accommodate Neo-Panamax container vessels, the berth was deepened from -15m to -17m and additional scour protection was required to maintain the stability of the stacked block gravity wall, while maintaining the other quays in full operation.

Solution

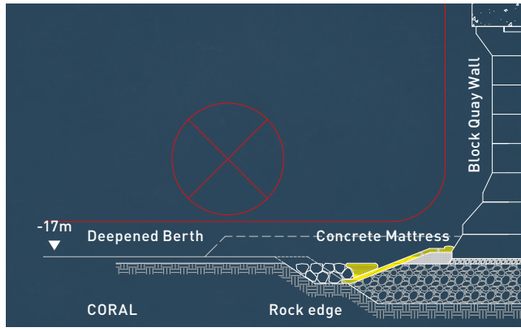
Proserve undertook design of the concrete mattress comprising a fully interlocking concrete apron of 300mm thickness, to 275m of quay wall, and an embedded edge protected with a rock falling edge apron. The mattress was sealed against the block wall and weepholes were fabricated into the mattress to provide tidal lag drainage.

The coral bed was initially thought to be resistant to erosion, however our due diligence approach identified that it was already scouring under the previous vessels on the quay. This scour assessment clarified that a falling rock edge detail was essential for durability of the mattress protection.

Working around vessels visiting the quays still in operation was managed by having the divers leave the water while vessels maneuvered with unfilled mattress fabric carefully ballasted. The fabric was then checked for position before filling.

BERTH DEEPENING

Red Sea Gateway Terminal, Saudi Arabia




Onsite Training

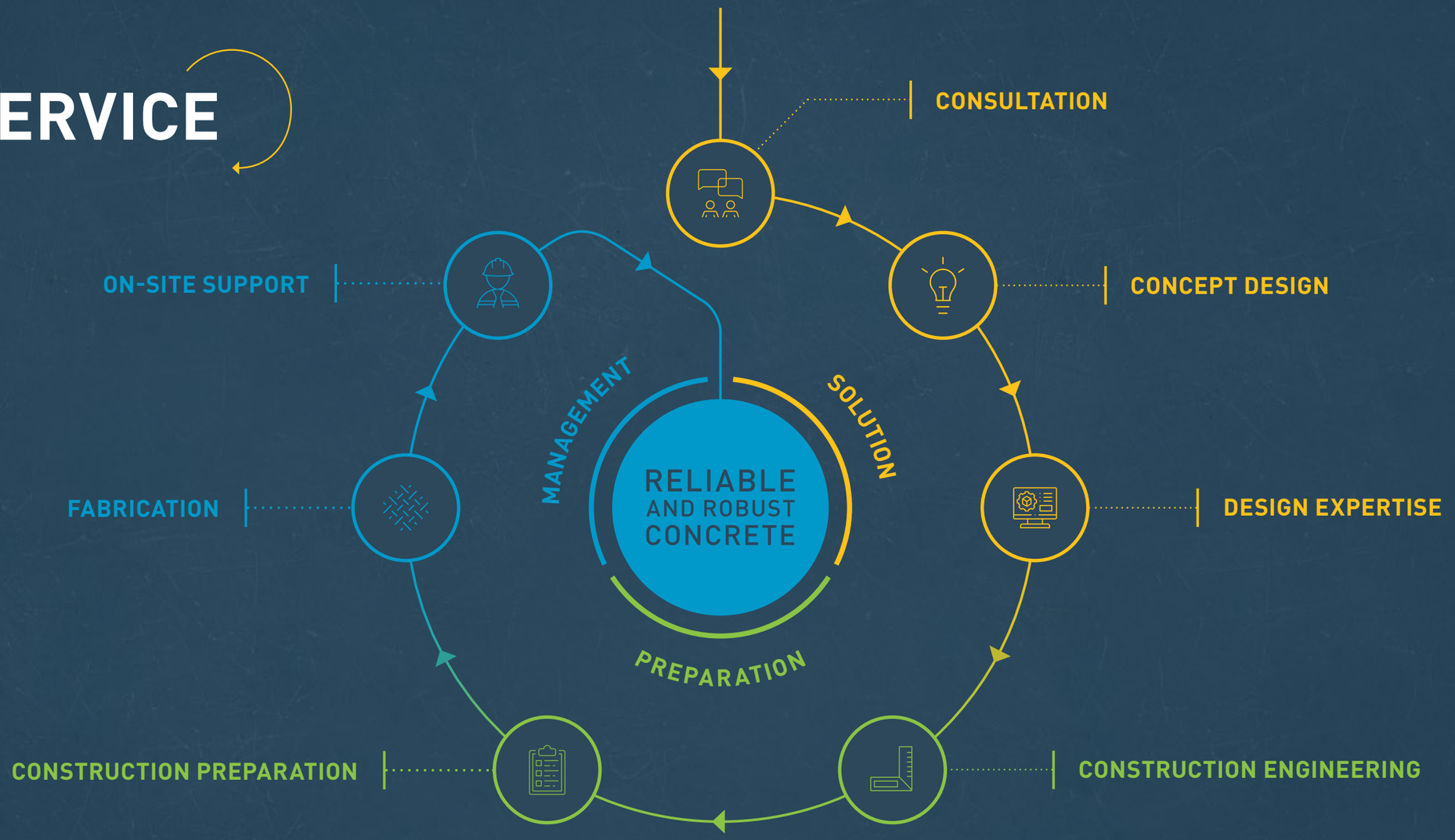

Mix Development

OUR SERVICE

On every project we use our experience and expertise to identify the core project requirements and working constraints. This allows us to create solutions that are practical and improve the constructability of the project.

George Hawkswood
Engineering Director

OUR SERVICE


CONSULTATION
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CONSTRUCTION PREPARATION
FABRICATION
ON-SITE SUPPORT
MANAGEMENT
SOLUTION
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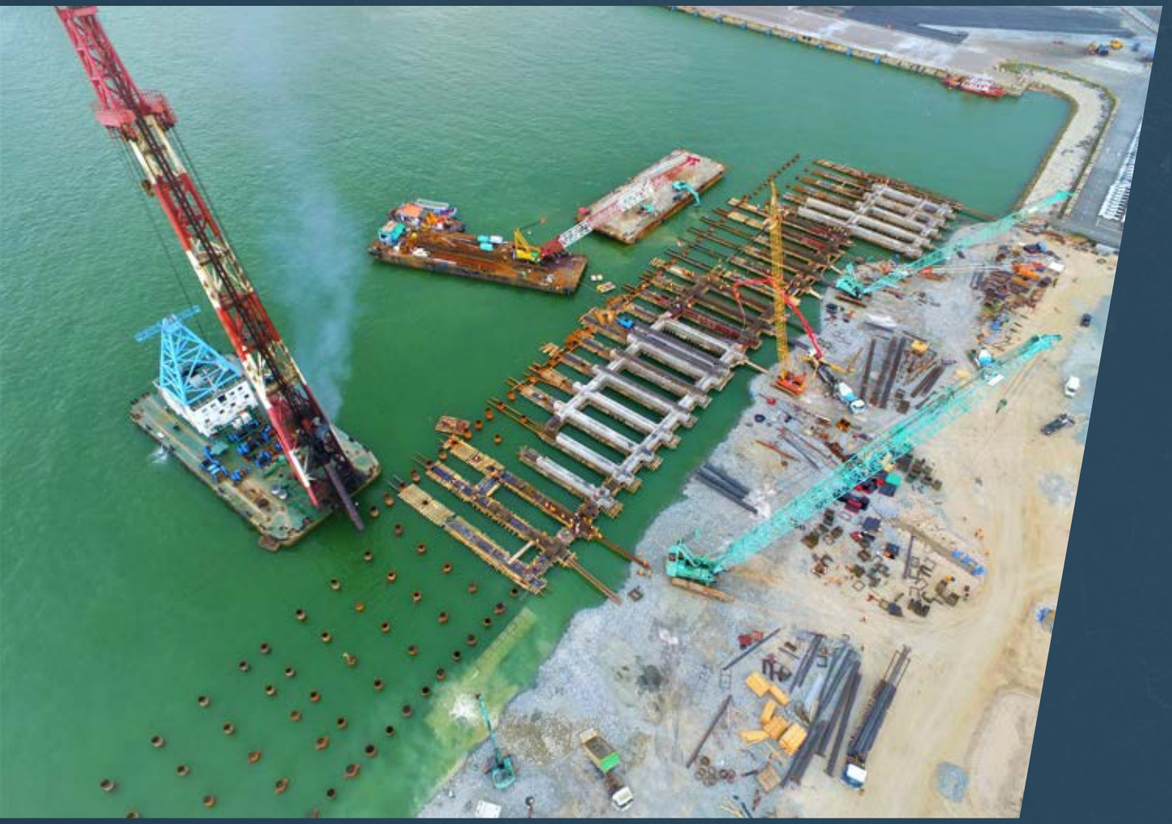
RELIABLE
AND ROBUST
CONCRETE

CONSULTATION

Establish the performance requirements of the concrete, assessing the working constraints and construction method options.



Consultation

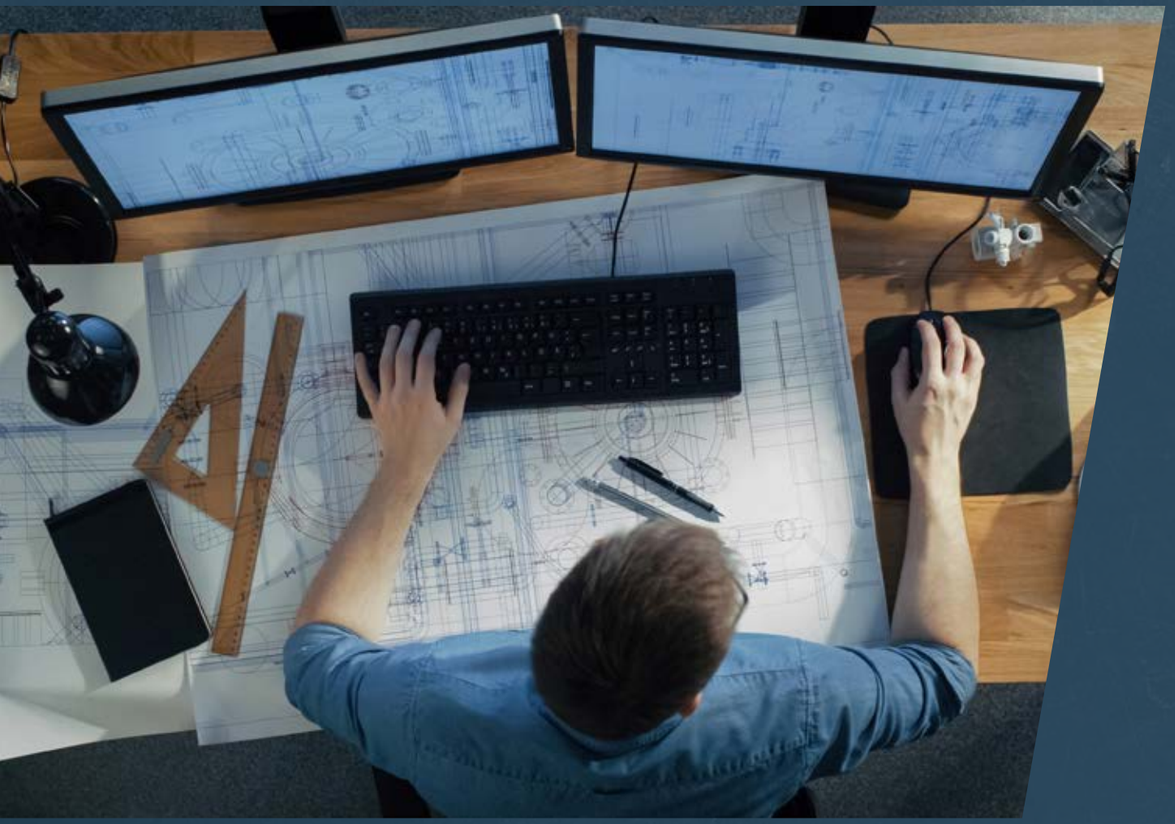
We use our experience and expertise to understand your project in depth and identify the requirements of the scour protection and the constraints on installation:

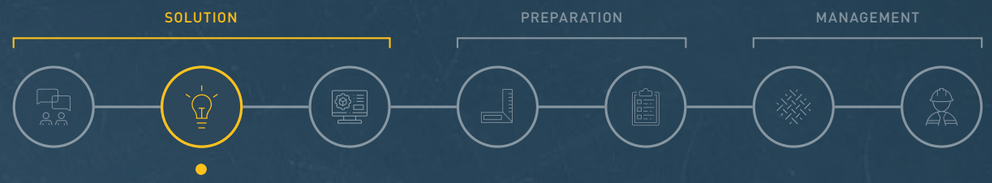
- Type of structure to be protected
- Design vessels
- Depths and clearances
- Berth/unberthing methods
- Bed material
- Environmental factors such as currents and waves
- Maintenance methods
- Plant and materials available
- Design life

This information provides the basis for our advice and design of the scour protection extent, edge details and how to achieve reliable installation.

CONCEPT DESIGN

Definition of a practical in situ concrete solution that achieves the project requirements.





Concept design

On each project, we convert the requirements and constraints identified into a practical project specific concept design through an assessment of:

- the client's brief
- the scour potential of the vessels' propulsion systems
- stability of the bed material
- areas of likely scour and consequence to the structure or berth
- waves acting on the scour protection
- impact of working conditions on construction
- application of our state-of-the-art design methods for sealed scour protection systems

Concept development & value engineering

We describe the scour protection concept that we have developed through:

- concept drawings
- outline construction methodologies, incorporating contractor input
- calculations
- installation budget estimates
- programmes for supply and installation
- materials and workmanship specifications

This bespoke concept and detailed information allows Designers and Contractors to make a fully informed appraisal of the solution and whether it is the best solution for their project

We can assist you from feasibility stage through design, tender, construction, maintenance and demolition.

DESIGN EXPERTISE

Designs using in situ concrete mattress to form a 'sealed' protection layer.

Design expertise

- Apply industry leading knowledge, experience and design methods to warrant an efficient scour protection design.
- Application of specialist knowledge on the propulsion systems of modern vessels, their usage in port, assessment of the associated scour locations and design to protect the wall structure and prevent failure of the scour protection mattress.
- Using the latest design methods built off the work of previous industry leaders as referenced in industry design guidance PIANC 2015 "Guidelines for protecting berthing structures from scour caused by ships"

  - Design drawings detailing the solution
  - Design calculations to justify the solution to state-of-the-art design methods
  - Design specification for quality of materials and workmanship
  - CDM duties for area of design undertake

CONSTRUCTION ENGINEERING

Defining the solution in detail, identifying risks, and incorporating mitigations into the construction method and formwork design.

Construction engineering

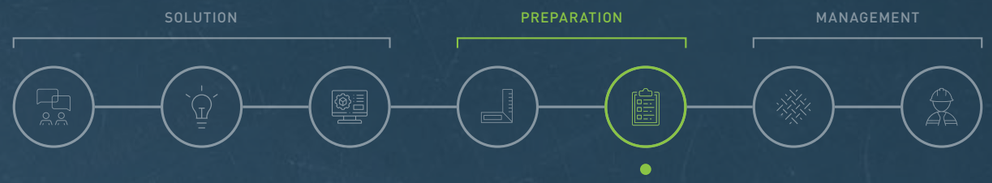
Taking the design/concept design and creating a robust construction method to achieve the required outcome even in tough marine construction conditions.

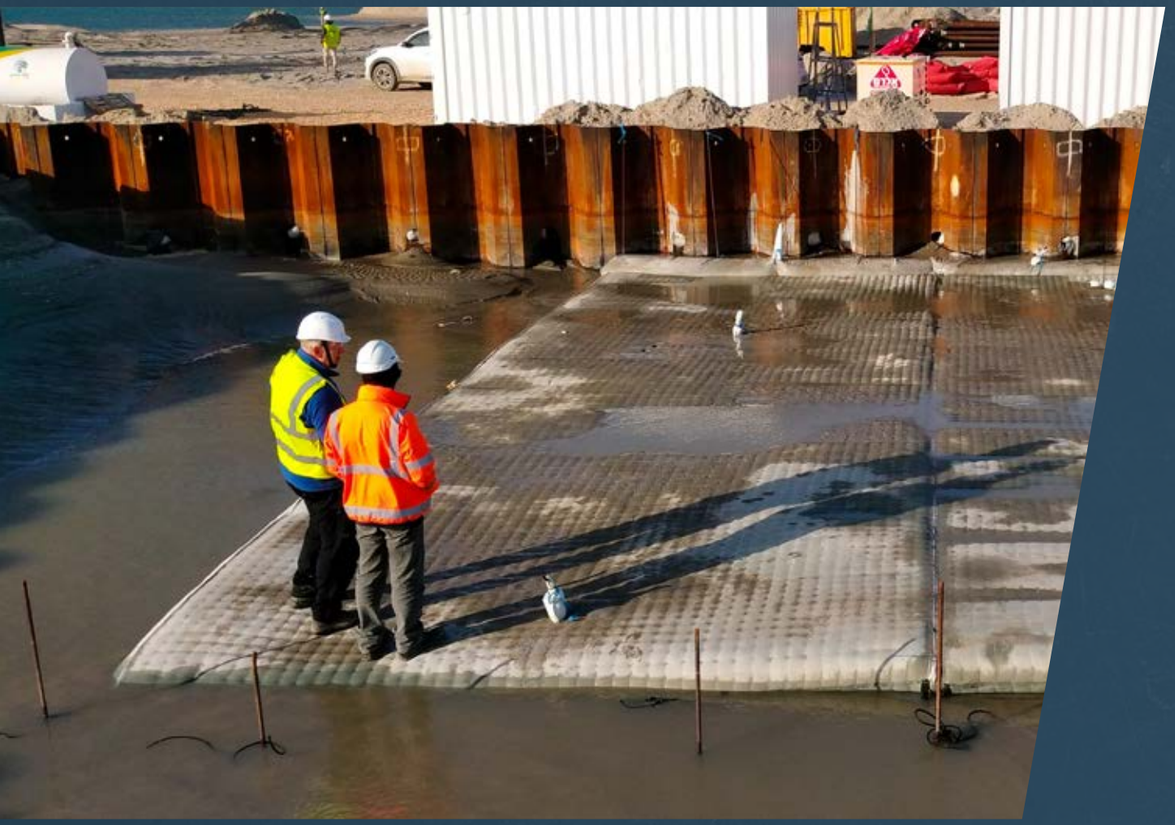
Quality assurance approach:

- Construction risk assessment – identify and control all aspects that could lead to insufficient construction quality
- Construction sequence – determine sequence of works to facilitate installation
- Temporary works design – adjust method of work to avoid risk of slip, restraint failure or mattress rupture
- Mattress engineering – Engineer all details of the mattress to achieve the design intent
    - Mattress joints to suit installation conditions
    - Seals to structures and piles
    - Filling points
    - Porosity
    - Restraints suitable to the working conditions
- Capture the above in installation guidance and quality assurance procedures.

CONSTRUCTION PREPARATION

Focused on managing the key construction risks, preparing detailed guidance, and training installation teams.





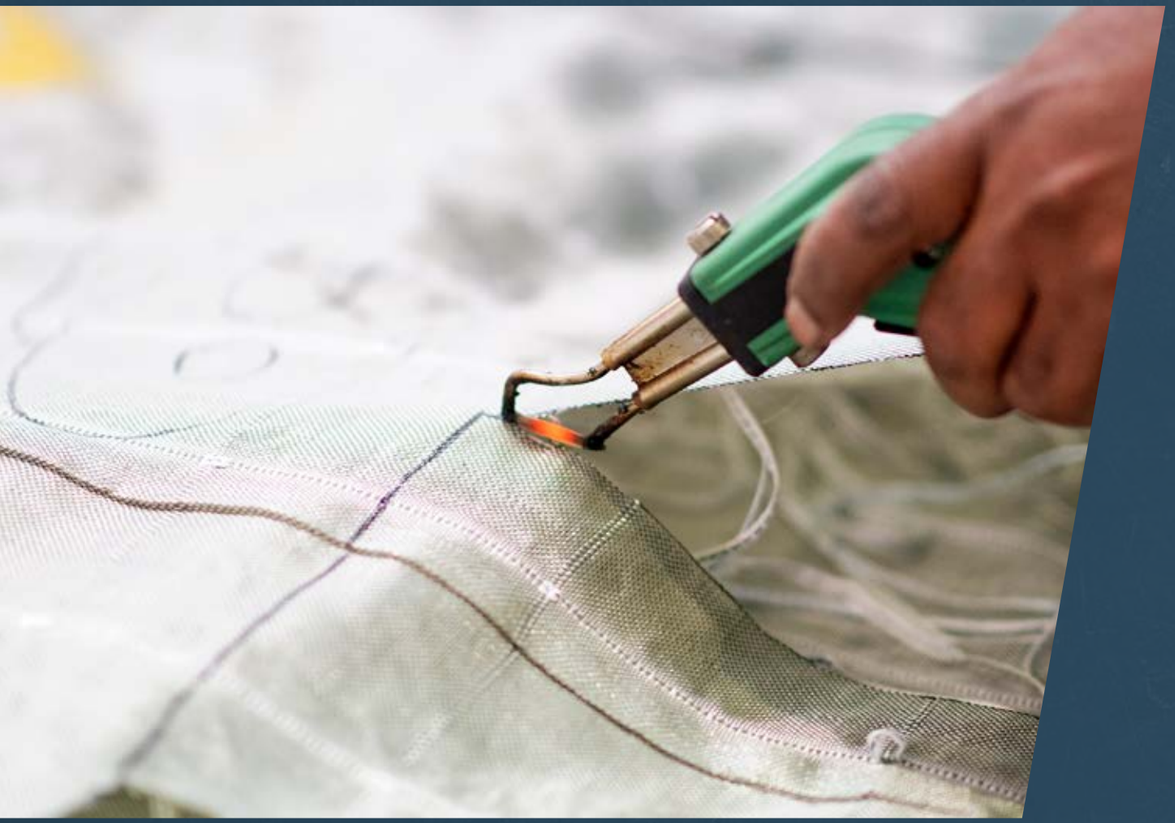
Construction preparation

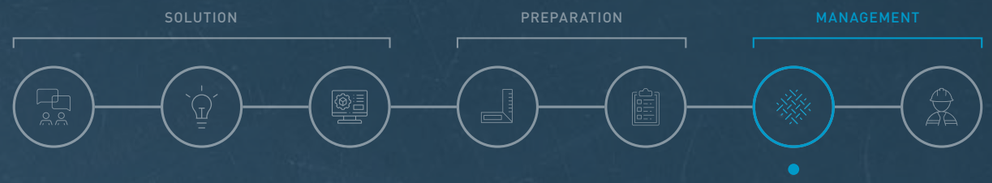
Supporting the site team to effectively plan and prepare for the challenges of underwater concreting.

- Identify all plant and materials required and advise the contractor on suitability
- Mix development and confirmation – ensure a reliably pumpable mix, suitable for concrete mattress filling is available and proven.
- Pumping trials to ensure concrete can be delivered to the mattress reliably
- Demonstration installation and filling – Train the installation team in the installation procedure for controlled marine construction
- Worldwide service: We train installation teams all over the world to be successful installing concrete mattress, even if they have no prior experience.

FABRICATION

Bespoke formwork, tailored by in-house technicians and quality approved by Engineers, delivered to site for reliable installation.





Fabrication

The formworks are tailored to ensure the required concrete specification is achieved, taking into account:

- Size
- Thickness
- Restraint methods to suit temporary works design
- Seals to walls, piles and structures
- Ball and socket shear joints
- Filler locations
- Compartment sizes

Undertaking fabrication off site enables the formworks to be accurately fabricated with high strength seams and details. Every formwork panel is individually inspected, arriving on site ready for installation.

ON-SITE SUPPORT

Expert Engineers provide specialist knowledge and support for successful construction throughout the project.

On Site support

Our engineers ensure that the robust plan developed in collaboration with the Contractor and installation team is effectively implemented from the outset of installation.

We provide training and support to ensure everyone understands the requirements of the construction method through:

- Mattress preparation for installation
- Installation in water training
- Filling sequence training
- Clarification of quality assurance procedures/control points

Installation support

Concrete doesn't have long before it sets, our support at the initial installation stage is focused on ensuring the installation team adapts to the project conditions and overcomes any challenges swiftly, quickly becoming experienced in how to reliably install the mattresses.

Once through the initial learning curve, our engineers provide 24/7 remote support with regular visits to site to support the installation team in overcoming any new challenges, maintaining the quality of construction throughout.

CONTACT

Get in touch for any technical or project assistance.

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Director & Principal Engineer

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