e-maritime

November 2020 PORTSMOUTH PORT HAIFA PORT SESIMBRA PORT

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Front Cover: Portsmouth Port – Cruise Berth Number 2: Levelling and Extension

Photo Credit: Portsmouth Port

Back Cover: Port of Haifa, Capping Beam, Israel

Photo Credit: RÚBRICA MARITIME

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Dear Readers

This issue is dedicated to three Ports and their recent extensions: ***Portsmouth Port in UK, Haifa Port in Israel, and Sesimbra Port in Portugal****.*

In the first article, Anisa Koci describes one of ***Portsmouth International Port´s most complex engineering projects: the lowering and extending of the existing cruise berth – a berth Number 2.*** *The completion of this project in July 2020 has since allowed the port to demonstrate the handling of ships up to 270m in length, hosting a number of cruise ships for repatriation, and with a number of calls scheduled for 2021.*

In the next article, Inma Gómez looks at two recent projects in which Rúbrica Maritime has been involved: ***The new Container Terminal in Haifa, Israel; and Sesimbra Port in Portugal.*** *In this article information on basic characteristics of the projects and design requirements that had to be taken into account is provided together with an overview of the equipment used and its utilisation.*

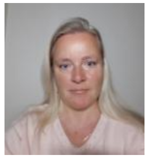
In the Haifa Port Project, Rúbrica Engineering was assigned to provide equipment and execute a total of almost 2,000m of capping beam. Underwater concrete movable formwork was used in the recent Sesimbra Port Project in Portugal.

I would very much like to thank all people and companies who have helped me prepare this issue; David Stork - thank you for reviewing this issue, for your valuable comments and your assistance, and Richard Martin – thank you for the language check.

On the following pages, you can also find more information on both magazines (e-maritime and e-mosty) and also our Editorial Plan including a Call for Papers for e-maritime March 2021 (Special Edition about Lighthouses; their design, construction and restoration).

Magdaléna Sobotková

Chief Editor



e-maritime

The magazine **e-maritime is an international, interactive, peer-reviewed magazine about vessels, ports, docks and maritime equipment**.

It is published on www.e-maritime.cz **three times a year:** 30 March, 30 June and 30 November.

September Issue is shared with the magazine e-mosty (“e-bridges”): “Bridges, Vessels and Maritime Equipment” which is published on 20 September on www.e-mosty.cz.

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We are happy to provide media support for important bridge conferences, educational activities, charitable projects, books, etc.

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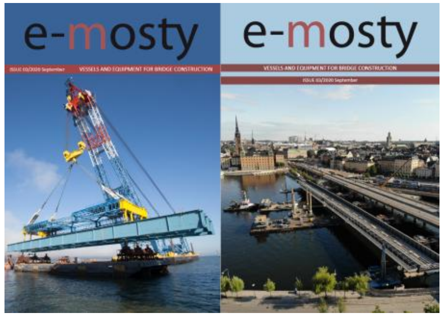

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Portsmouth Port, Cruise Berths, UK

CRUISE BERTH LEVELLING AND EXTENSION

PORTSMOUTH PORT, UNITED KINGDOM

Anisa Koci, Senior Project Manager, Portsmouth Port

INTRODUCTION

With a rich maritime heritage Portsmouth has been known for its naval links and ocean going trade for centuries. However, Portsmouth International Port, formerly known as the commercial or continental ferry port, has only been in operation since 1976.

The Port is owned and operated by Portsmouth City Council. Initially it offered just one route to France from a small section of reclaimed harbour front. Over the decades, the Port has grown extensively. It is now known as Britain's Best Connected Port with more destinations than any other UK Port.

Portsmouth International Port offers a wider range of ferry routes than any other UK port. Millions of passengers travel to France, Spain and also rely on the port to reach destinations closer to home such as the Isle of Wight and Gosport.

The Port is an essential hub for commerce and the travel industry, taking people on journeys and contributing towards the nation's tourism and visitor economy.

Portsmouth is a critical shipping route for Channel Island trade. With daily sailings carrying predominantly freight, there are regular exports of cars, building materials, food and drink supplies, clothing and utilities.

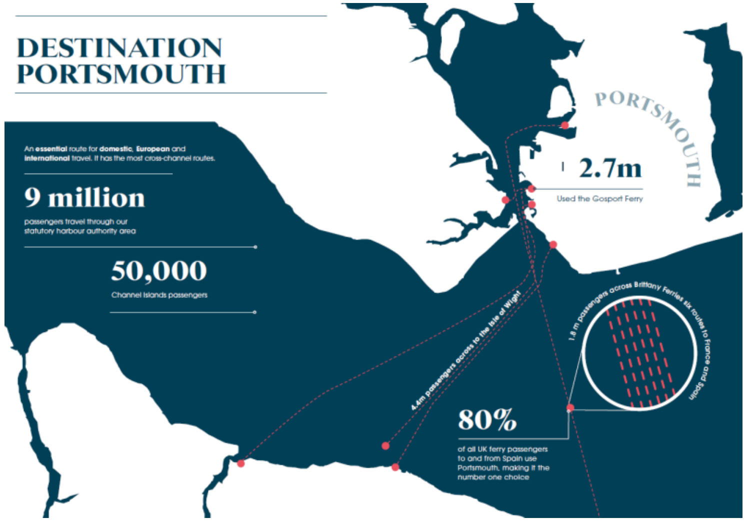


Figure 1: Anisa Koci, Port Senior Project Manager

The Port is also an increasingly popular destination for cruise ships. There are dedicated facilities for cruise customers, with passengers keen to explore the world-class attractions on the doorstep.

← Figure 2: Major routes and passenger statistics in 2019

The port also has two deep water, multi-functional conventional berths, operated by Portico. They handle project cargo, dry bulk and break bulk, along with fresh produce. This includes the majority of bananas eaten the UK.

In 2011 the Port opened its new terminal - part of a £16.5m investment in new passenger facilities. It is one of the most environmentally friendly buildings in the UK. It is heated by thermal sea energy and cooled by the coastal breeze which is captured by wind catchers on the roof.

The Port is a significant contributor to both the local and national economy, and a critical industry for many businesses in the supply chain. Millions of pounds are generated through employment and trade, with associated wages providing an additional boost for the economy. It is in a great position to continue thriving and leading a substantial role in the UK's marine and maritime industry.

Figure 3: Berths in Portsmouth Port

PROJECT OF LOWERING AND EXTENDING CRUISE BERTH

In January 2019, approval was given to one of Portsmouth International Port´s most complex engineering projects, the lowering and extending of the existing cruise berth – a berth Number 2.

The completion of this project has since allowed the port to demonstrate the handling of ships up to 270m in length, hosting a number of cruise ships for repatriation, and with a number of calls scheduled for 2021.

The original berth was at height for passenger embarkation, which restricted loading.

<u>Client:</u> Portsmouth City Council / Portsmouth International Port

<u>Contractor:</u> Knights Brown

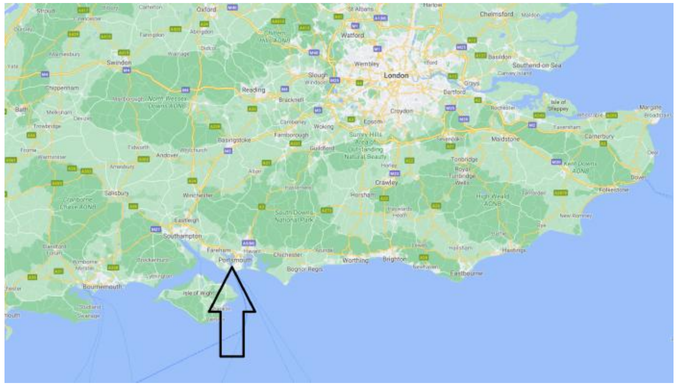
<u>Designed by:</u> Marbas Group Limited

<u>Form of Contract:</u> Design and Construction NEC4 OptionA

<u>Procurement Method:</u> Competitive tender

<u>Project Sum:</u> £6M

<u>Timescales:</u> November 2019 – July 2020



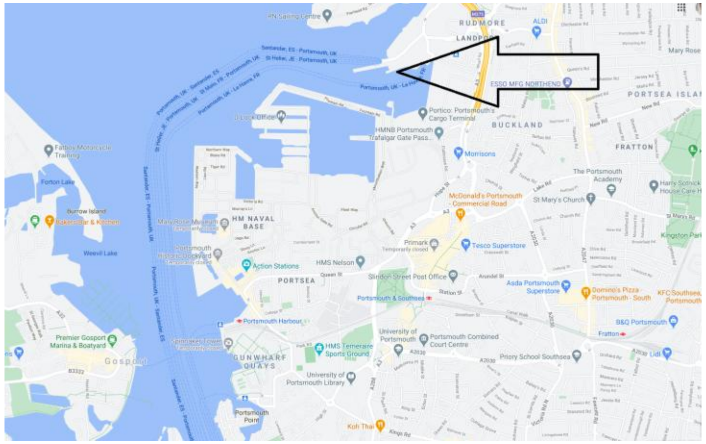


Figure 4: ↑ Location of the Port, and

Figure 5: ↗ The cruise berth on the map

Source: maps google

Construction work has since lowered the berth by 2.4 metres, allowing the loading/unloading of ships at dock level, and boarding via a gantry walkway.

The berth has also been extended by 40 metres with the addition of a further freestanding mooring structure, known as a dolphin, with a carousel structure weighing in at about 60 tonnes.

In summary the key marine activities and sequencing were as follows:

- Scour protection at the end of the finger jetty locally removed to allow pile installation;
- Installation of 21 tubular piles to the berth extension, up to 33m in length and 1.2m in diameter. Up to 14m of each pile sits below water, with 3m above the waterline and 16m below bed level;
- Installation of the new dolphin;
- Modifications to dolphin 1;
- Installation of the precast and in situ concrete to the deck extension;
- The levelling and extension of No 2 berth alongside the installation of the new dolphin structure (approximately 30m offset seaside from dolphin No 2).

The project had a short timescale so the project was programme driven which, along with a number of other factors, made it a very challenging project.

Figure 6: Tubular piles on a barge

Figure 7: Installation of the tubular piles

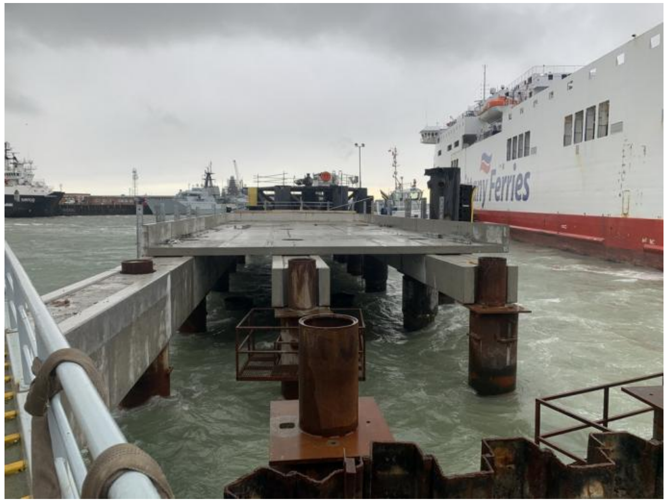


Figure 8: Installation of planks and beams

Figure 9: Piling phase from a barge used for the construction

Five months were allowed to design the scheme, appoint a contractor and be ready for construction works to begin in November 2019.

The berth was programmed for completion in the spring of 2020 ready for the start of the cruise season.

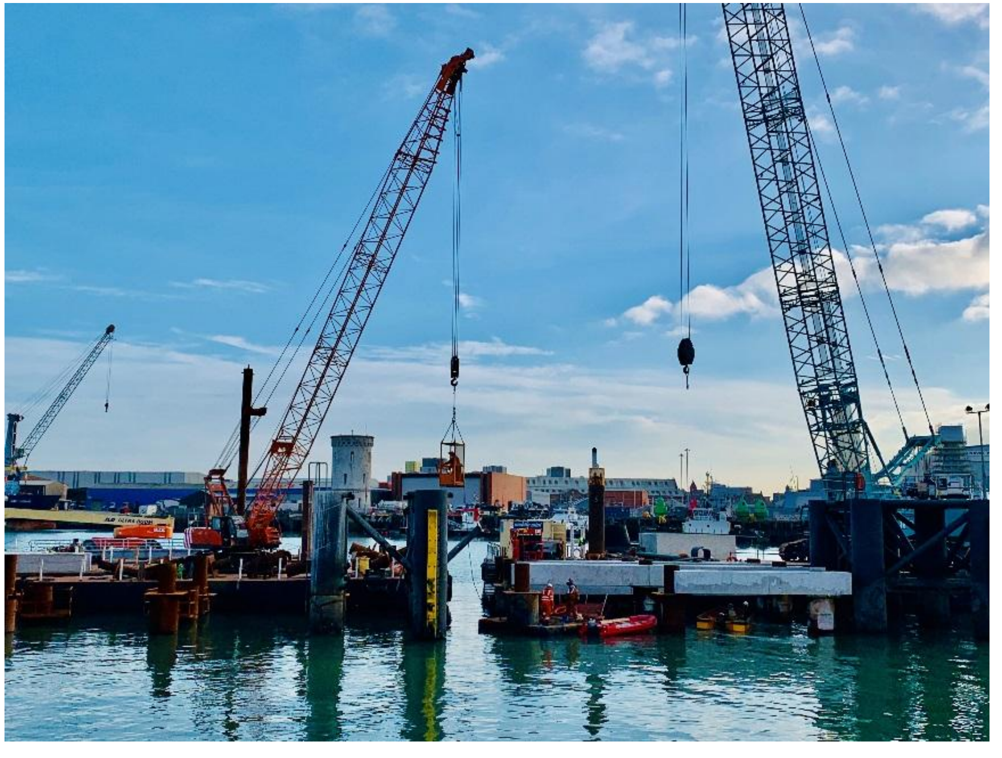
Undertaking the works in a live marine environment and during the winter months required a truly collaborative approach between Portsmouth International Port and Knights Brown to successfully deliver the project.

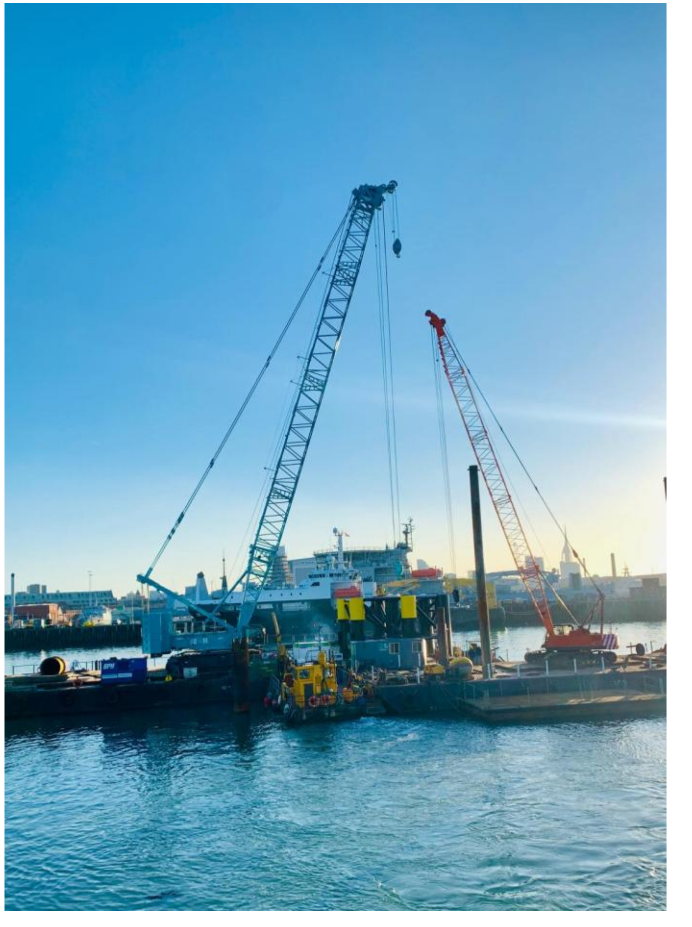
Throughout operations and to achieve a tight deadline the teams worked on two fronts simultaneously.

Marine-based operations took place from a spud leg barge and supply barge.

The spud barge was loaded with a 330tonne crawler crane fitted with the largest hydraulic pile driving hammer in the UK, with a drop weight of 20tonnes, a 16tonne shroud and a maximum impact weight of 300tonnes.

The barge loaded with the crane was towed to Portsmouth, where it was fitted with the BSP CG300 hydraulic pile driving hammer, which has to lower the piles below the water line and drive them 16m below bed level.





Figures 10 and 11:

The crane and hammer drove the central pile, before the 61-tonne dolphin carousel structure was lifted over it.

Figure 12: Demolition of the Berth, barges alongside the Berth

Figure 13: Berth 2 - Lighting columns installations

Figure 14: Installation of Dolphin 2

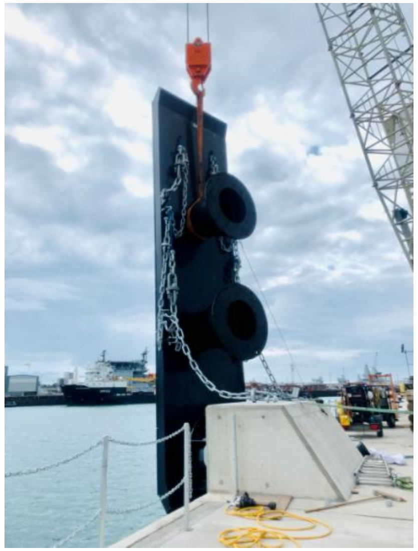
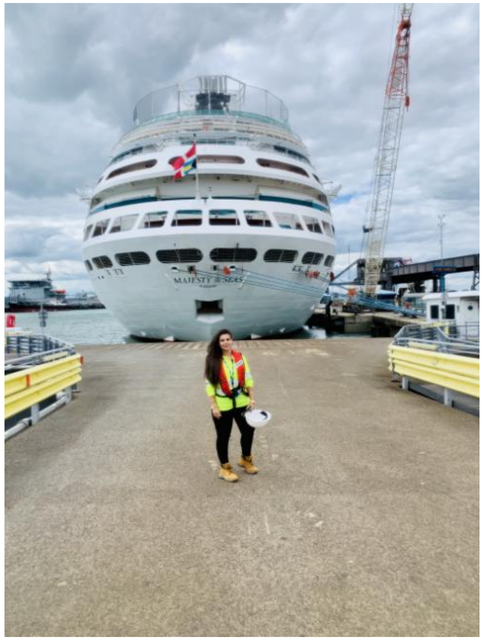


Figure 15: Double Con Fender Installation

Figure 16: Shibata Fenders Installed



← Figure 17: Anisa Koci to see Majesty of the Seas moored alongside the completed berth, after overcoming the challenges to deliver one of the ports biggest projects.

"Seeing her standing beautifully alongside the new pier was one of the proudest moments of my career."

On land, work took place using 160 and 80tonne crawler cranes, with a third 80tonne crane barge providing lighter lifts.

The CKE3000G type crane used by Knights Brown is the largest of Kobelco Cranes range in Europe.

The newly extended berth is the equivalent of two football pitches in length, and more than 1000cubic metres of concrete were poured on top of tubular piles (30-60tonne each) to give the structure the required strength to accommodate the large cruise lines.

The very windy weather in the winter and the two storms in autumn added to the list of challenges. This was especially the case with critical heavy lift operations such as the installation of the 61 tonne carousel structure at dolphin No 3 and the partial demolition and removal of the existing finger berth structure.

Despite the threats posed to the project, the berth extension was successfully completed in July 2020, with the construction being put to use the very next day as the port welcomed the largest cruise ship to ever sail into Portsmouth.

Royal Caribbean's Majesty of the Seas weighed in at over 73,000 GT, in tonnage and stretched 268 metres along the berth.

Operating in a marine environment always poses significant challenges, for what can appear a straightforward project.

The Covid19 pandemic was a hurdle that nobody could have predicted, and hit the project even before reaching the UK as one of the critical elements of the scheme, the fenders, were being manufactured in Malaysia.

This had a significant impact on the project programme of works.

The berth has since hosted a number of vessels including Sea Dream 1, the UK's first international cruise call since sailings were suspended, and Brittany Ferries new ship 'Galicia' – the longest ship to have ever joined the fleet at 215 metres.

References:
https://www.portsmouth-port.co.uk/

Figure 18: Galicia, Brittany Ferries' brand-new ship serving routes to Spain and France. She undertook berthing trials in Port on 13 October 2020 before her entry into service for passengers in December 2020.

Galicia is the longest ship ever to have graced the Brittany Ferries fleet at 215m, hosting 3km of "lane metres" for freight and passenger traffic. She is the first new ship to join the fleet since 2009 and is the first since the company announced a multi-million euro investment in fleet renewal back in 2017.

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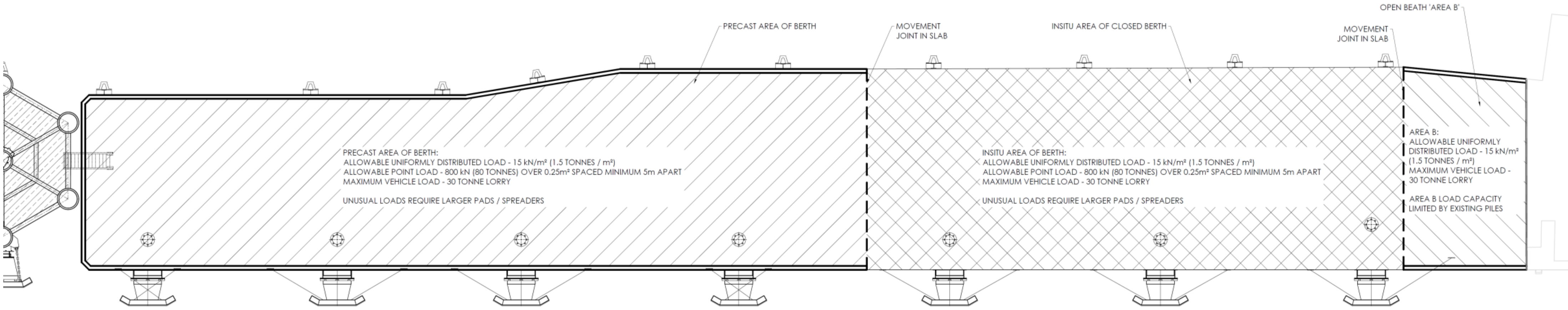


ALLOWABLE BEARING PRESSURE
TO COMPLETED DECK: BERTH 2
(SCALE 1:150)

Plan of Extension and Alterations to Berth 2 Portsmouth Port - Allowable Bearing Pressure

GENERAL NOTES

1. This drawing is to be read in conjunction with all other relevant As-built and other drawings and specifications.

2. No dimensions are to be scaled from this drawing.

3. Unless noted otherwise all dimensions are in millimetres and all levels are in metres from the site datum.

4. The loads expressed in this drawing are in accordance with the loading section in the calculation document.

5. The loads shown do not apply to the existing quay blond Area B. No design checks have been undertaken for the existing, unmodified quay to confirm allowable loads.

6. The quay is designed for a single 100 tonne crane limited to lifting a maximum of 18 tonnes at a maximum of 5m radius. The crane can track across Area B, but must not carry out lifting activities or position outriggers onto 'Area B'.

November 2020

Figures 19 – 21: Majesty of the Seas at the Portsmouth Port

MARITIME PROJECTS USING MOVABLE FORMWORK

Inma Gómez, Division Manager, Rúbrica Maritime

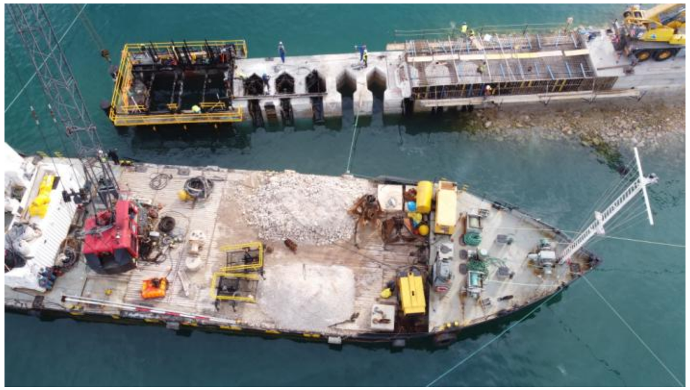
INTRODUCTION

In this article we will look at two recent projects in which Rúbrica Maritime has been involved: The new Container Terminal in Haifa, Israel; and Sesimbra Port in Portugal.

In the Haifa Port Project, Rúbrica Engineering was assigned to provide equipment and execute a total of almost 2,000m of capping beam.

Underwater concrete movable formwork was used in the recent Sesimbra Port Project in Portugal.

We will bring information on basic characteristics of the projects, design requirements that we had to take into account, and we will provide an overview of the equipment used and its utilisation.



↑ *Sesimbra Port, Portugal. Photo Credit: Etermar*

← *Port of Haifa, Israel. Photo Credit: Port of Haifa*

Port of Haifa, Israel

THE NEW CONTAINER TERMINAL IN THE PORT OF HAIFA, ISRAEL

1. PORT OF HAIFA - GENERAL INFORMATION

The Port of Haifa is the largest, leading port in Israel. It also serves as a regional transshipment hub. The port is located in a natural, deep-water and protected bay in the Mediterranean. It lies in the northern part of Haifa and stretches approx. 3km along the coast.

It consists of numerous terminals, enabling handling all kinds of cargoes as well as receiving large passenger ships. The port operates all year round.

Figure 1: Location of Haifa Port on the map
Source: maps google

The Port is operated by the Haifa Port Company, which is a government corporation committed to continue operating as a growth engine for Israel's economy and as a source of livelihood for the tens of thousands of employees and workers in the various circles operating in the Port.

2. EXPANSION OF THE PORT

In 2018 The Israel Ports Development & Assets Company Ltd. (IPC) started a major expansion of the Port of Haifa through the construction of the Haifa New Marine Container Terminal (HNMCT).

The expansion includes the reclamation of a large area to the northeast of the Kishon River; the extension of the Main Breakwater by approximately 900m; dredging new entrance and approach channels, a harbour basin, and a turning circle; and the construction of a new East Breakwater, and East and Lee Revetments.

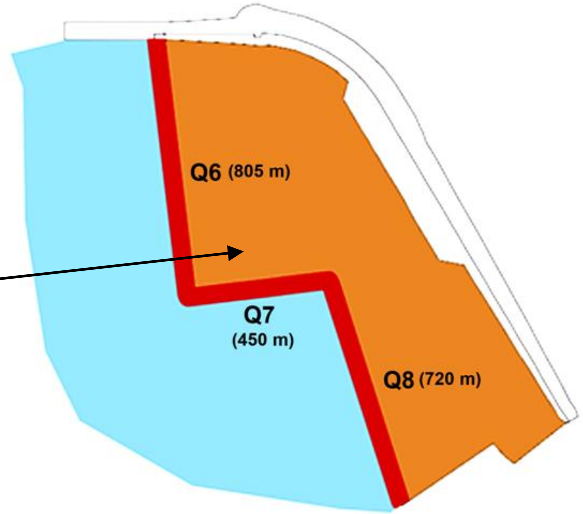
On the approximately 90 hectares of reclamation, a container terminal will be developed featuring three quays: Quay 6 which will have a length of 1,150m and three berths for ships ranging between 200 and 330m in length plus a 400m long E-Class ship; Quay 7 will be 500m long with two berths for ships in the 130 to 170m length range; and Quay 8 where only small general cargo ships are expected to berth.

The general arrangement of the existing Port and the proposed container terminal, including existing and planned port structures, is shown in Figure 2.

The new container terminal is being built by the Israeli construction firms Ashtrom and Shapir Marine & Civil Engineering and is due to open in 2021. Shanghai International Port Group (SIPG) won an international tender to operate the new terminal for a period of 25 years once it is completed.

In its initial phase the Bay Terminal will be capable of handling 800,000 TEU container movements annually and planned future expansions to the terminal could handle up to an additional 700,000 TEU.

For the construction of the new container terminal in the Haifa Port, Rúbrica Maritime supplied the equipment necessary for providing a total of almost 2,000m of capping beam. It was executed on a sheet pile wall in three different quay alignments.



Figures 2 and 3: General Arrangement of the Existing Port of Haifa and Planned New Terminal with a detail on the right

Figure 4: Visualization of the completed project

PROJECT OVERVIEW

Client	Israel Ports Development & Assets Company
Contractor	Ashtrom - Shapir
Implementation	2017 - 2018
Capping beam	Rubrica
Executed in	2017

3. DESIGN CONSTRAINTS

Once the order to manufacture the equipment was received, further details about the construction site were required before development could proceed.

It basically included information on the project, what was going to be built and conditions that affect the design of the equipment.

On one side there is the situation at site which we can see, i. e. when the team arrives at its destination, what elements there already are with which our formwork has to interact or which interfere with it. Also we have the conditions or design requirements established by a project.

In this project, a capping beam was built on a sheet pile wall with the special feature that the formwork had to allow, at the same time, the construction of a series of rear beams attached to this capping beam. On these rear beams later the beam for the crane rail was built.

Figures 5 and 6 show the situation at site with elements already executed and areas to be built for a better understanding of what had to be manufactured with the equipment supplied by Rúbrica.

Description of the area

The elements that made up the place where the equipment was going to work were the following:

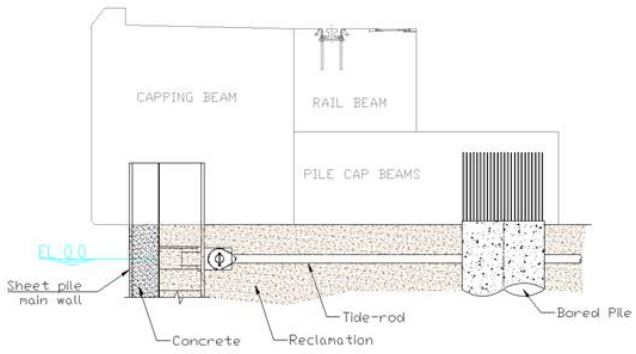


Figure 5 showing the situation at site

- A sheet pile wall configured by IPNs + AZs already driven in and crowning at elevation +1.40
- Already placed tie rods tying this sheet pile wall to another back wall of sheet piles.
- The space between both sheet pile walls filled with sand covering the tie-rods (braces between sheet piles).
- And finally, parallel to the sheet piling wall, there was a line of concreted piles up to an elevation of +0.50 on which the rear beams were to be executed and therefore with the connecting reinforcement protruding out of the ground.

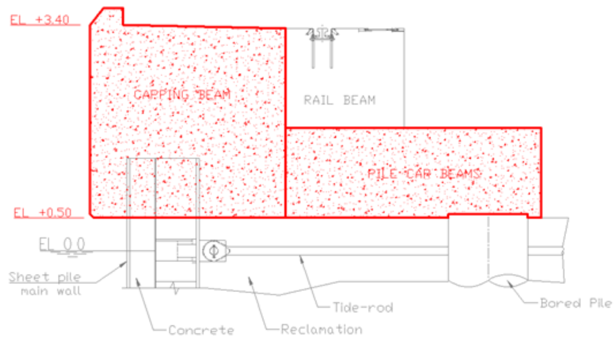


Figure 6 showing the areas to be built

Design requirements established by project

- The first element to take into account was the elevation of the lower face of the capping beam that was at + 0.50m. That is, there was only 50cm between the underside of the beam and sea level, which means that a part of the equipment had to be submerged.
- On the other hand, there was armor protruding from the rear beams to connect them with a beam for the crane rail that will go over them.
- Another important element to consider was that the designer required being a wire mesh control joint approximately every 15 meters in addition to the construction joints indicated in the plans for each quay alignment.

- A major element to also be taken into consideration was that the supporting and driving surface of the formwork, which was filled with flush but not compacted sand, will be temporarily flooded.
- Other singular elements that influenced the design of the formwork are:

    - Bollards
    - Fenders
    - Tie-down pit
    - Cable channel drainage
    - Outlets from the general dock drains
    - Ladders

4. EQUIPMENT OVERVIEW

As two structures had to be built with different geometries and also different modulations, the whole equipment was subdivided into three independent units that work together.

In Figure 7 you can see in various colours the three different sets that make up the equipment. On one side, in green, is the formwork for the main capping beam on the sheet pile wall, on the other hand, in magenta, there is the formwork for the rear beams and finally, in blue, a transport carriage that served to hold and transport the other two sets.

On the following pages the operation of the equipment is shown in a conceptual way.

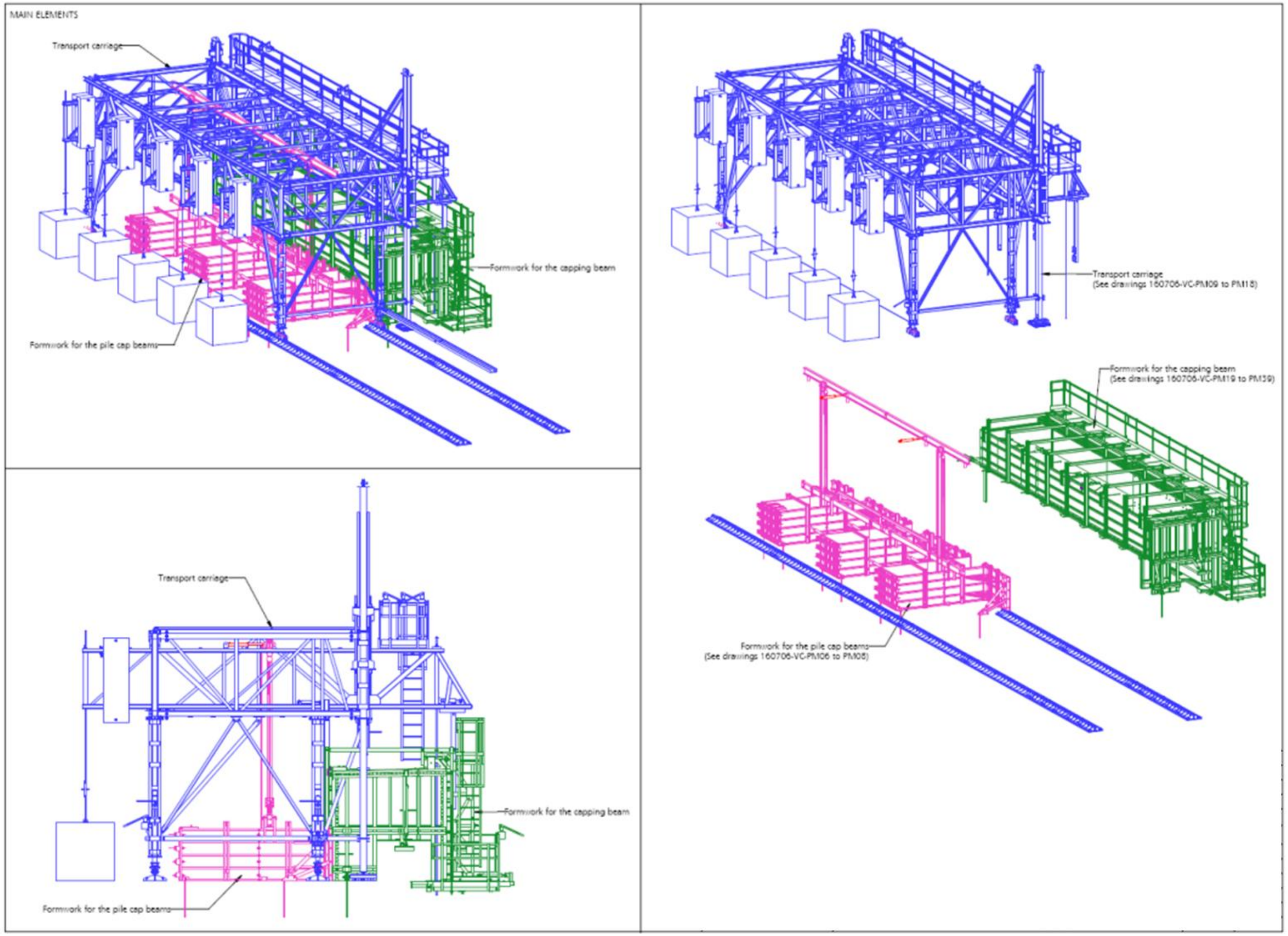


Figure 7: Main elements of the structure

In the place where there is the capping beam, a section had to be built – it is where there is a large volume of suspended concrete.

So the critical element of the formwork and from which the rest of the structure will be designed is the bottom panel for this suspending area.

This bottom panel is supported laterally from the sea-side panel and additionally it has a hanging bar in the cantilever concreting area.

These two fixing points of the bottom panel are joined at the top to a series of transverse lattice beams.

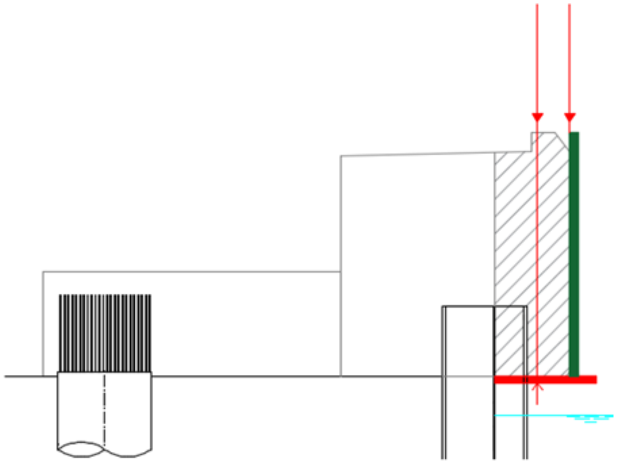


Figure 8: Support elements of the inferior panel. Sea-side panel and hanging bars.

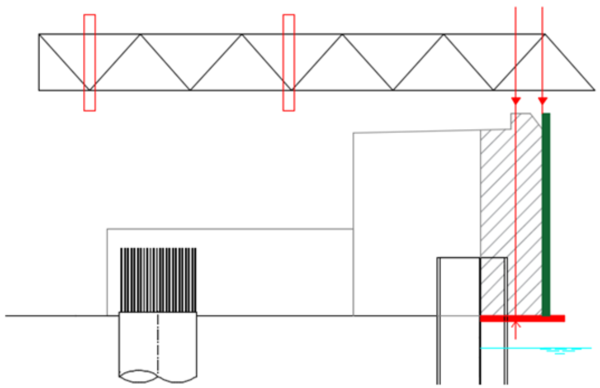
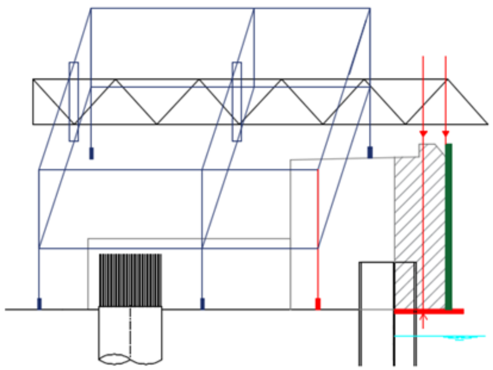


Figure 9: Transverse beams fastened to two longitudinal lattices conforming the upper part of the transport carriage

In total there are 5 transverse beams along the entire casting length. And these beams are in turn fastened at two longitudinal lattices that join them all. The transverse beams go through the longitudinal beams and are attached to them.



→ *Figure 10: Supporting points of the transport carriage. Three in front of the concreting section and two at the rear part*

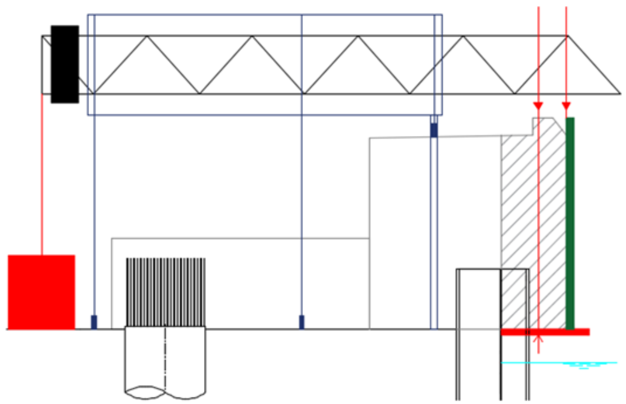


Figure 11: Stabilization elements of the structure. Fixed counterweights on the structure and concrete blocks to tie it up during concreting.

The two longitudinal lattices have four support points, two in front of the concreting section and two at the rear.

The rear support on the land side is made on the sand filling while on the sea side the leg rests on the section already made.

At the front, both legs rest on the side of the section, on the sand fill, and there is also an additional prop in front of the capping beam section to support the loads during concreting.

The particularity of this structure is that over the entire casting length, which is approximately 15m, it has no intermediate support points. Therefore, the longitudinal lattice on the sea side will be the one that receives all the loads transmitted by the hanging elements of the bottom panel and sea panel.

To guarantee the stability of the formwork and prevent it from overturning towards the sea side, a permanent counterweight was placed in each transverse lattice, thus ensuring the stability and avoid overturning when it is empty and during the advance of the structure.

In addition to these permanent counterweights, the end of each transverse truss has to be tied to dead weights that rest on the ground before pouring the concrete. This ensured stability to tipping during filling as only the counterweights of the structure were not enough.

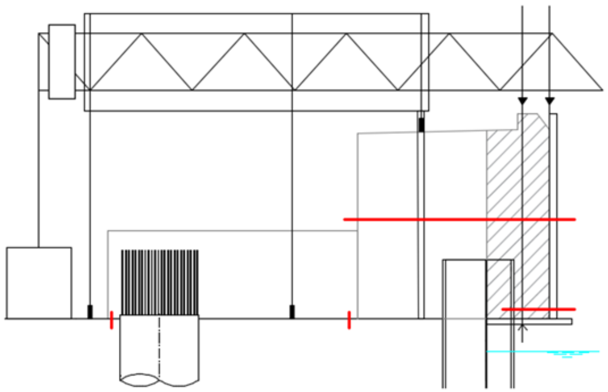


Figure 12: Elements to ensure horizontal stability

Regarding the horizontal stability of the formwork, the following elements are acting:

- The land and sea side panels are tied by means of a tie bar above the sheet piling wall and with upper props above the section to be made.
- In addition, the lower part of the sea side panel is tied to the sheet pile wall.
- And finally the main formwork is tied to the formwork of the rear beams that is anchored to the ground.

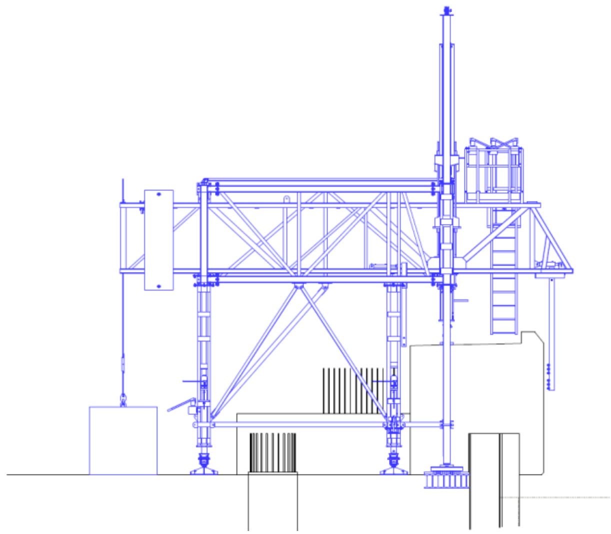


Figure 13: General view of the transport carriage

5. TRANSPORT CARRIAGE - ANALYSIS

The transport carriage is made up of two longitudinal frames in which 5 frames or transverse trusses are mounted, 3,575mm apart. The 4 legs with the wheels for the movement of all the structures come out of the longitudinal gantries.

One of the client´s requirements was that the reinforcement of the main capping beam should be placed ahead of the segment to be poured, therefore there cannot be anything in the structure within the section of the beam that could interfere with this reinforcement at the time of advance.

That is why the two longitudinal frames with the wheels to transport the structure are placed on the inside part of the capping beam.

However, as the load during concreting is so big, only these lateral legs are not be able to support it and therefore it is necessary to place an additional support point, closer to the suspended section.

→ *Figure 14: Rebar cages already placed in front of the formwork*

As this leg remains within the section of the capping beam, it has to be raised before advancing the structure to save the reinforcement of the next segment and be lowered again once it has been advanced before carrying out the new concreting.

Three of the four wheels of the structure, the two on the land side and the front one on the sea side, rest on the sand filling, while the rear wheel rides on the concreted section of the capping beam, aligned with the auxiliary front concreting support.

Due to the high weight of the structures, plus the concreting loads, and as the driving surface is an uncompacted sand fill, the three legs that go on it cannot rest directly on the ground, they rest instead on a rail dimensioned to dissipate the loads that the structure transmits to the ground, thus preventing the formwork from getting stuck in it.

Thus, two wheel configurations are fixed in the structure, the ones that go on rail are a DEMAG DRS160 two-wheel boogie.

Figure 15: DEMAG DRS160 Two-wheel boogie

Figure 16: Sea-side rear wheel

The sea-side rear wheel was designed and manufactured by Rúbrica and sized to withstand the 13 Tn to which it was be subjected during the movement of the formwork.

As the client wanted to make short cycles, to avoid potential damage caused by the wheel to the concrete if it has not cured enough when moving forward, some UPN profiles were placed there so that this wheel circulates on them.

At this rear point on the sea side, aligned with the wheel, there is a support strut to help the wheel supporting the load that appears at that point when concreting.

In the drawing on the next page there are shown the different support points of the transport carriage with the loads for two scenarios, for the empty formwork, own weight of the structure, and under working conditions, during pouring.

There is a concreting section with a volume of 117.5m^3 and a weight of more than 280 Tn. All this without any intermediate support, the supports are separated as can be seen in the drawing by 17.5m. One of the most critical points came from the existing loads on the two support struts on the sea side.

The land-side supports are subjected to very small loads of 3 and 5 Tn, while the sea-side supports, during concreting, have loads of almost 50 Tn in the front leg and 67 Tn in the rear leg. The rear leg rests on the section of the previous segment made so there is no problem, but the front leg is on a surface of uncompacted sand that is obviously unable to support this load.

For this reason, the site had to prepare the ground in the support area of the front strut, making a concrete footing that they embedded in the ground and on which they placed a load distribution plate.

Figure 17: Rear land-side view of the equipment

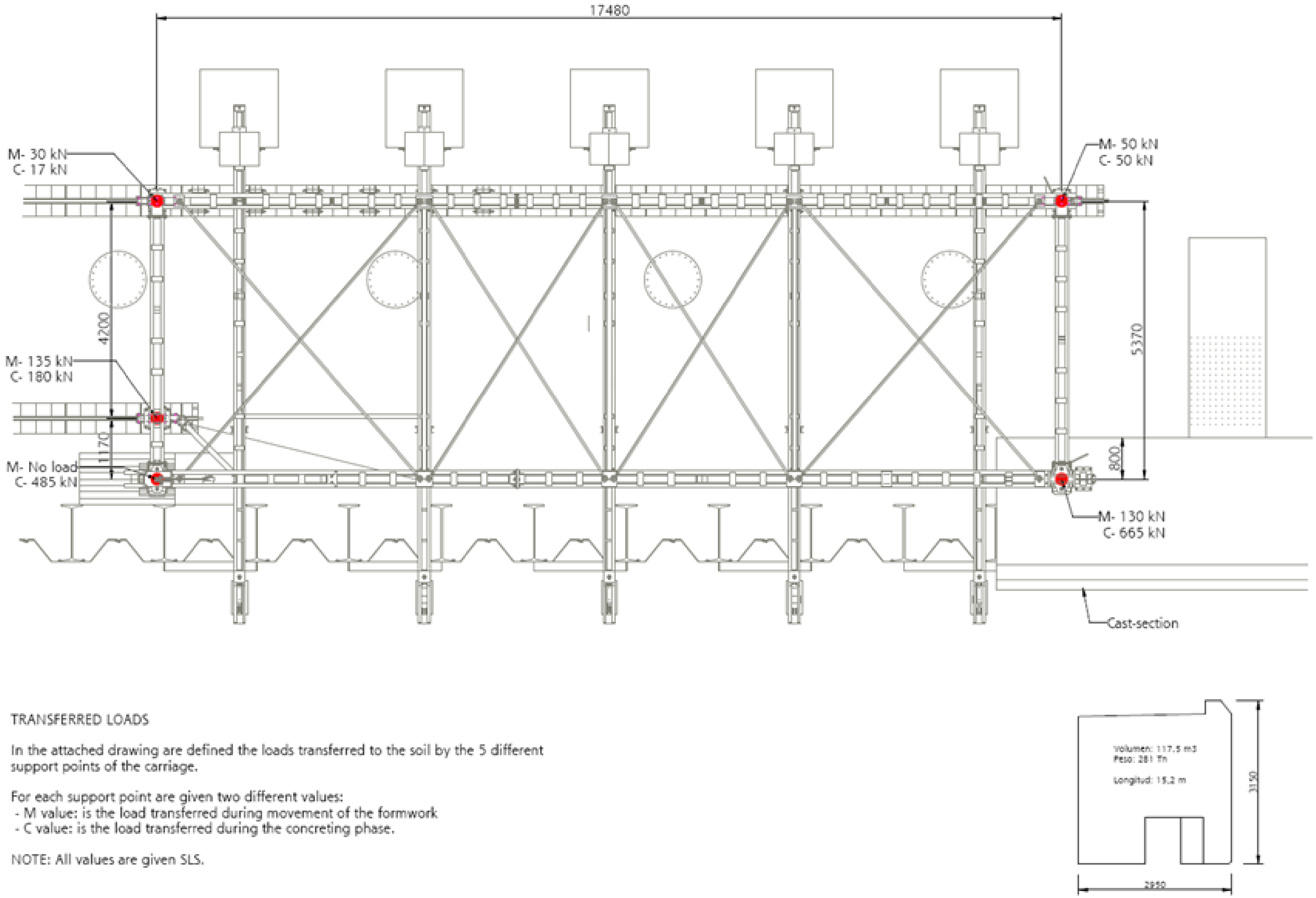


Figure 18: Diagram of the loads acting on the support points of the transport carriage, both while empty and when pouring

6. CAPPING BEAM - ANALYSIS

The formwork for the capping beam is made up of two side panels (sea side and land side) that hang from the transport carriage, then the bottom panel that is attached to the sea panel and also during the concreting with hanging bars tying it to the transverse trusses of the carriage, and finally the front closure panel that is fastened to the two side panels on one side and then propped up against the sheet pile wall and against the ground.

One of the main handicaps in terms of design was the design of the bottom panel in the outer area of the sheet pile. This had to be adapted to the geometry of the sheet pile wall, which had considerable deviations in placement and which varies depending on the alignment where it is working.

Figure 19: Rear sea-side view of the equipment

Figure 20: Sea-side panel and bottom panel being transported for its assembly

So the bottom panel was designed as a straight panel that is placed against the outer face of the sheet pile, and then it is equipped with some plates that come in and out of the panel to cover the inner gap of the sheet pile. These pieces can move in the two axes of the plane of the lower panel to be adjusted according to the possible deviations of the sheet pile.

As for the side panels, both the sea and the land panel have some hanging arms to get connected to the transverse lattices of the carriage.

In the lattices there are hydraulic cylinders connected to the two hanging arms at each end of the panel that allow to move them horizontally to detach them from the concrete during the stripping and advance of the structure and later return them to their correct position prior to the filling.

Figure 21: Bottom panel against sheet-pile wall with AZ shaped panels to cover the inner gaps of the wall

Figure 22: Sea-side panel and bottom panel placed against sheet-pile wall

Figures 23 and 24: Detail of the sea panel assembled, and the hangings arms that will enter the transverse lattice

Figure 25: Hanging arm and transverse lattice connected with the cylinder.

7. REAR BEAMS

Formwork for the rear beams is a relatively simple structure.

Firstly, the panels are modular to enable adjustment of the distance between beams according to the relevant alignment.

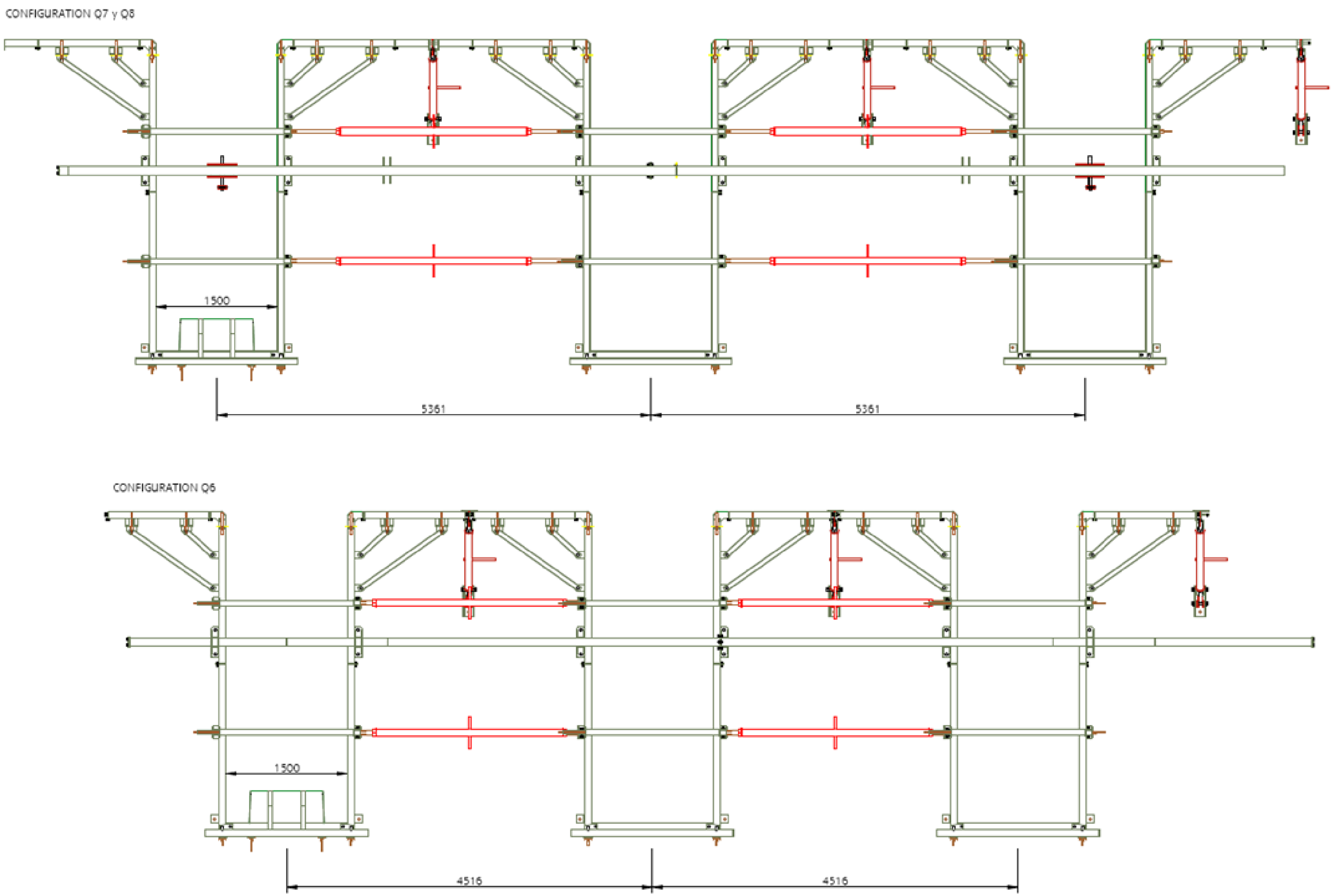
The second and most important point is that this formwork has to move together with the main formwork and in each setting it has a different position with respect to the main structure in the longitudinal direction.

The solution is that all panels are connected by tensioners; for stripping the tensioners retracted, thus detaching the panel from the concrete but remaining as a rigid assembly.

This is set as a beam in the upper part which is connected with a hanging beam placed in the transverse frames of the carriage by means of two pulley carriages.

To advance the general structure, the formwork of the rear beams is raised with these manual pulleys until it is above the connecting steel of the rear beams with the rail beam.

Once it has been moved to the next concreting position, and still hanging in the air, it is moved longitudinally with pulley carriages and lowered to finish adjusting the assembly to the new settings.



The distance between rear beams varies depending on the alignment to be built. For this reason the formwork had to be modular, to get adapted to the two possible existing scenarios.
The image shows the assembly of the formwork to build Q7 and Q8 alignments, where the distance between beams is 5.361m and to build Q6 alignment where the distance is 4.516 m.

Figure 26: Configuration of the rear beams

Figures 27 and 28: In the images you can see the sheet pile wall dividing land and sea, the pile heads protruding from the sand fill and the connecting reinforcement of the same.

Figure 31: Pouring of one segment of the capping beam

Figure 29: Struts connecting and positioning rear beam panels. And a strut securing the rear beam formwork to the ground to counteract the horizontal thrust of concrete

Figure 30: Pouring of the rear beams

Figure 32: Chain hoist hooked to the lifting beam of the rear-beam formwork to raise and transport it


Port of Sesimbra

UNDERWATER CONCRETE FORMWORK
SESIMBRA PORT, PORTUGAL

1. SESIMBRA PORT - GENERAL INFORMATION

The Port of Sesimbra is located to the south of Lisbon, Portugal approx. 10km from Setúbal.

The area of port jurisdiction extends from the interior area to the exterior breakwater and also extends to the repair and building shipyards zone, located at the Nort-East part of the Port.

The Port of Sesimbra has important port infrastructure covering the different activity sectors that are established there. These are fishing, leisure, navigation and maritime-tourism activities.

The area dedicated to leisure navigation and maritime-tourism occupies 11.2 hectares of the port infrastructure, of which 1.4 hectares are operated by the Clube Naval de Sesimbra.

2. PROJECT INFORMATION

The Setúbal Port Authority is investing in the construction of a new dock at Sesimbra Port. The aim of the project is to improve the conditions of shelter and safety of fishing vessels, by protecting the docking areas during adverse weather conditions.

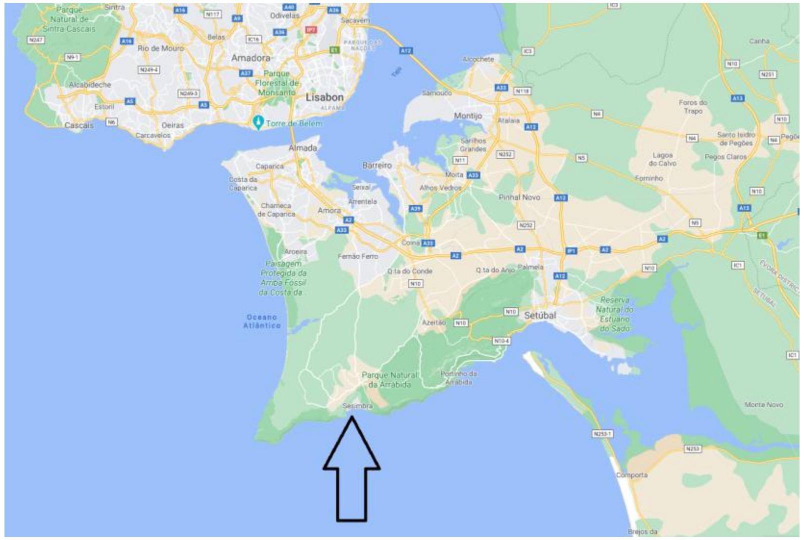


Figure 33: Location of the Sesimbra port   Source: maps google

PROJECT OVERVIEW

Client	APSS – Administração dos portos de Setúbal e Sesimbra, S.A.
Contractor	Etermar engenharia e construcao
Implementation dates	2020 - now
Underwater formwork	Rubrica
Executed in	2020

November 2020

It also aims to increase the number and length of berths facing the port and also to protect its parking area from vessels.

The quay will have a width of 5.00m, 182m in length, crowning height at +5.00 (ZH) and service funds at -4.50m (ZH), and will consist of simple concrete modules type NOREF that will be cast “in situ” and that will be based on a foundation beam at the level -5.00m (ZH) constituted by selected rockfill.

Above the modules, a reinforced concrete beam / slab with 1.40m of height will be made “in situ” in modules separated by expansion joints.

3. INTRODUCTION

This article describes equipment including formwork for the construction of a submerged gravity quay wall and the quay wall above the water level in the fishing port of Sesimbra, Portugal.

The initial project involved the construction of this quay wall by placing precast blocks, a bottom row of 2m high blocks and then three more rows with 2.2m high blocks to achieve the total quay wall height of 8.6m.

The project was awarded to the construction company ETERMAR, one of the leaders in maritime construction and an expert in submerged concrete techniques.

They presented an option to construct the entire section of the wall "in-situ", in a single concrete pour for each section which has an effective length of 7.5m.

The equipment to be used had to be capable of replicating the initial geometry proposed by the blocks. These included vertical slots in the wall 7.5m high designed to dissipate wave energy.

The total length of the quay to be built is 181.5m. It has a cross section of 8.6m high x 5m wide in the main body.

To provide both stability and protection of the main wall its base has a width of 7m.

The base of the wall is at a level -5.00m and the top of the wall is at +3.60m. A capping beam 1.4m high sits on top of the wall.

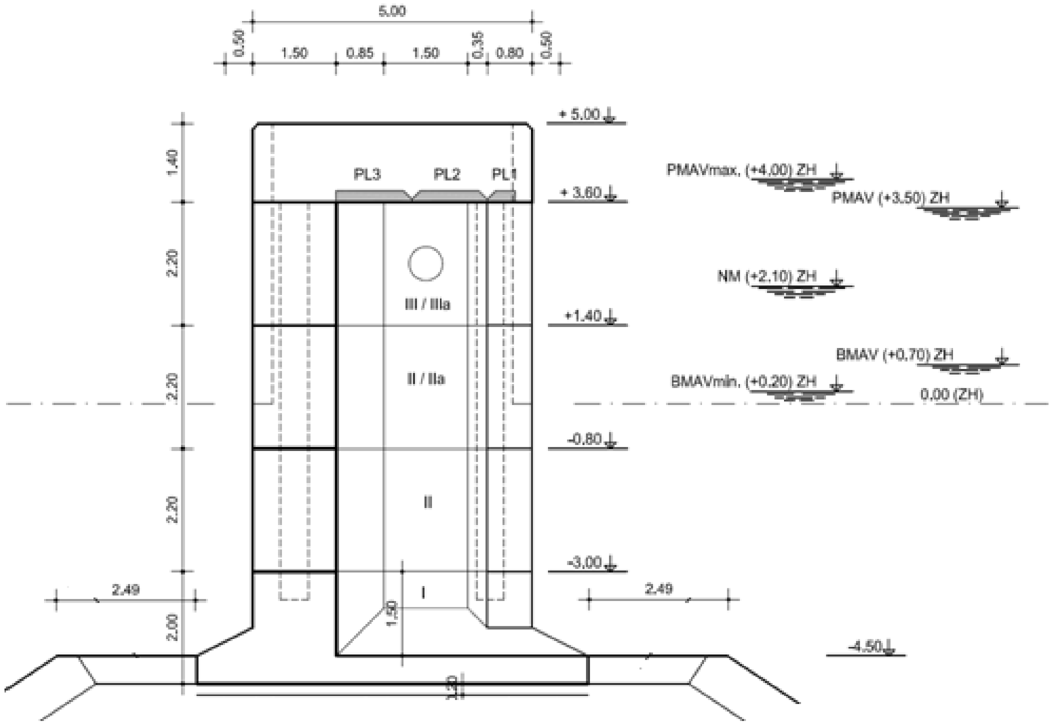


Figure 34: Section of the initial idea proposed by project where the gravity wall is built with precast blocks

4. GENERAL DESCRIPTION OF THE EQUIPMENT

The submerged wall concreting formwork with emergent crown and section has the following measurements:

- Base 7m wide x 1m high
- Main body 5m wide x 7.6m high x 7.5m long

The main structure is a three-sided formwork composed of a front panel, two side panels and a rear gantry.

The side panels hang from the back of the rear gantry. The gantry has two hydraulic cylinders to open/close the side panels.

In the lower rear part, these panels have wheels that can be moved away from the wall to help separate the panels from the concrete and then repositioned to assist in guiding the formwork as it is advanced along the quay to the next section.

The internal slots are created using formwork constructed to create a core around which the concrete is poured.

In the front part of the structure, the panels hang from a series of pins, also with hydraulic cylinders at two heights, to allow horizontal stripping of the side panels.

To avoid deformation of the side panels during concreting, they are tied together by through bars at 5 levels.

The front panel is equipped with two active floats. These comprise of two tanks mounted on the front panel that are filled with air to raise the formwork to enable it to move forward without the use of large cranes.

They are then filled with water so they sink into position once the desired working position is reached.

The rear part of the formwork moves over the section on driving wheels fitted to the rear gantry.

On the side where the internal slots are located the wheel moves on a steel rail to bridge the gaps left by the internal slots.

To counteract the thrust created by the concrete on the front panel the formwork will have an anchoring system to the previous section.

To avoid flotation produced by air trapped in the internal slots and the upthrust of the sloping face of the footing the rear part of the panels have shear keys placed against the previously concreted section while the front part is fastened to submerged concrete blocks arranged on each side of the formwork.

The side panels are slightly longer than the casting length to overlap with the previous section to improve alignment between sections and help prevent possible concrete leakage during the pour.

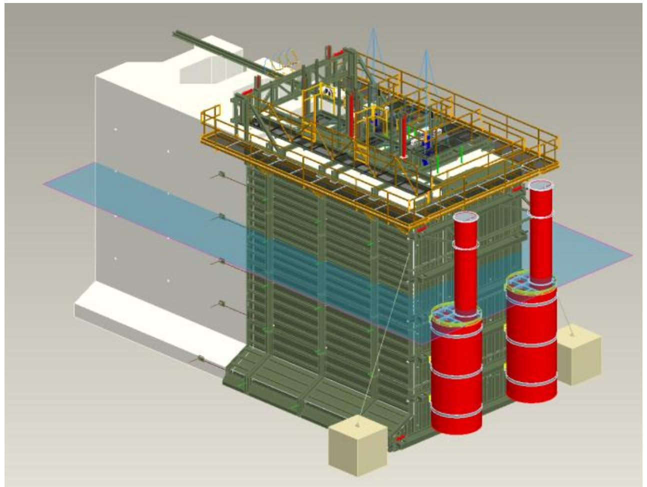


Figure 35: General view of the underwater formwork

The formwork has, in its inner part, a series of internal slots to create the area of dissipation of the waves in the concreted section.

These internal slots go from the top of the wall to the beginning of the footing. They have a height of 7.6m and the lower face of the slot has an 8º inclination.

Finally, the equipment has a tremie concrete plant with two independent hoppers to facilitate concrete pouring in a uniform way.

5. CONDITIONS OF THE DESIGN

In this particular project, the most critical and determining factors in the calculation and design of the structure are the flotation of the equipment and the external pressure differences on it due to the variation of the tide and therefore of the submerged or emerged part of the structure at any time.

The flotation of the equipment is caused by two factors:

- On one side there is the sloping face of the side panels to go from the width of 7m at the base to a width of 5m in the main body of the wall; this surface creates a vertical thrust area of 16.8m^2;
- There are the three internal slots that represent a total vertical thrust surface of an additional 13.8m^2.

Variation of the tide must be considered since the internal pressures of the concrete on the panels are partially compensated by the pressure of the water on the outside of it.

Variability of the water level has an effect on the concreting speed which depends on the water level, to avoid exceeding the maximum pressures considered in the calculation of the equipment.

Another important factor in the sizing of this equipment is the number of tie bars to be placed between side panels.

As it is equipment that works underwater, the handling of these elements must be carried out by divers, whose cost per hour is high, and therefore a balance must be sought, reducing the number of bars without over-dimensioning the structure.

6. ANALYSIS OF THE STRUCTURE ELEMENTS

FRONT PANEL

The front panel consists of 5mm thick metal sheet, IPE100 vertical profiles every 385mm and IPE400 horizontal ribs approx. every 1,400mm.

At both ends of each horizontal rib, a D70mm pin is used to hang the side panels and guide them in the stripping manoeuvre.

The panel has two height-adjustable legs to level the front part of the formwork and it has 4 hydraulic cylinders for the opening and closing of the side panels.

As indicated in the general description,two active floats are mounted on the outside of this front panel that allow for the front part of the structure to be raised or sunk to facilitate its advance movement and to reposition it at the new working point.

These floats are made up of two parts, a main body that is a D1900mm cylinder in the part that is always submerged and an extension with D750mm reaching the upper platform. These are operated from the structure.

On the inside face of this panel is screwed half of one of the internal slots formwork and a panel to create a hole that acts as a shear key, locking one segment against the other and thus avoiding transverse displacements due to the action of the waves against the wall.

LATERAL PANEL

The side panels are made of 5mm sheet metal, horizontal profiles IPE120 each 375mm and vertical ribs formed by UPN160 facing each other, leaving a 50mm gap to allow the tying bars to pass through.

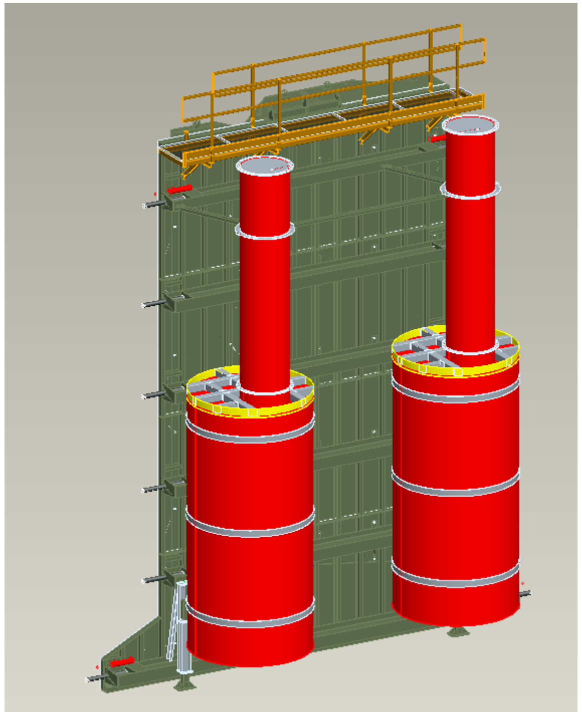


Figure 36: Active floats placed in the front panel

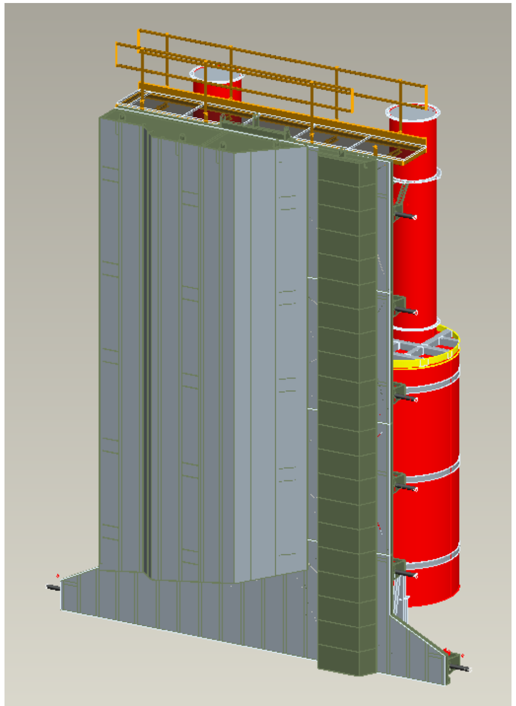


Figure 37: Inside of the front panel with half of the internal slot and the panel to create the shear key between segments

Both side panels are tied together to support the concrete thrust by 15 through bars DW26.5, 3 columns x 5 rows, and a line of 4 upper props (IPEs220) just above the section to be concreted.

The upper props, in addition to tie the side panels, serve to support the internal slot formwork and to counteract part of the vertical thrust exerted by them. In one of the side panels, the bars press against a wedge-box that facilitates the release of the load on the bars after concreting.

In the lower rear part of these panels there is a take-off wheel, activated by a hydraulic cylinder that serves to detach the panel from the concrete during stripping and to also guide the formwork structure when relocating to the next section.

Finally, in the upper rear part, each side panel has a structure that carries the rear gantry from which they are hanging.

REAR GANTRY

This is a lattice structure with wheels and support spindles from which the side panels hang. During concreting, the wheels are free and the gantry rests on the spindles on the upper face of the previous segment.

To move the structure forward, the wheels are put in contact with the ground and the spindles are retracted. The wheels have vertical adjustment operated by bottle jacks. At both ends of the gantry there is a hydraulic cylinder for the opening/closing of each side panel. Also in the rear gantry the hydraulic unit is mounted to operate all the cylinders of the structure.

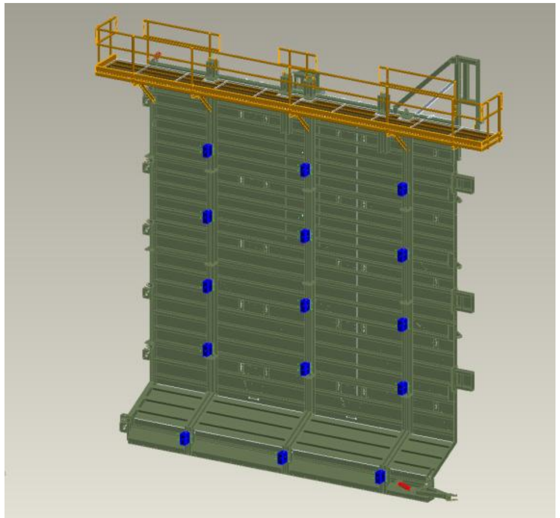
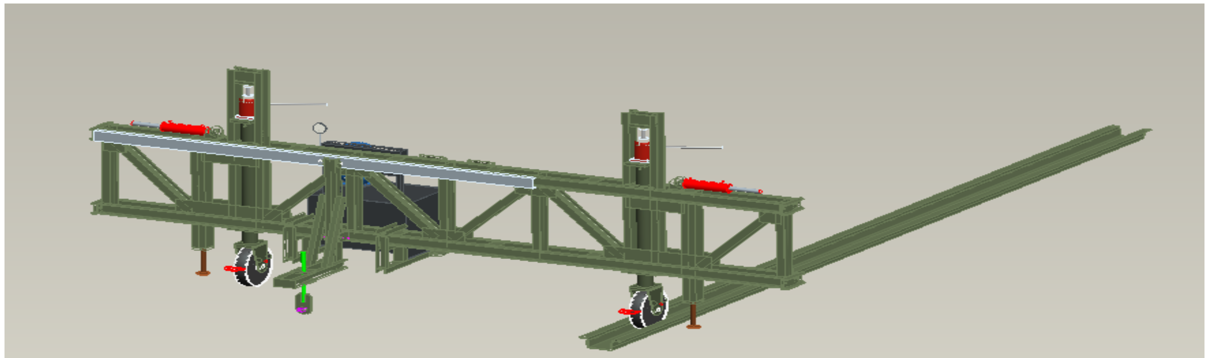


Figure 38: Lateral panel with wedge-boxes to release load on tying bars

↓ *Figure 39: General view of the rear gantry*



INTERNAL SLOT FORMWORK

The formwork makes 7.5m long segments, leaving 3 slots in each of them designed to dissipate wave energy.

Each segment ends in the middle of one of these slots so that it has two full slots in the middle and two halves, one half in the front and half in the rear part.

The front half internal slot formwork is attached to the front panel and moves together with it, being only disassembled in the last section where it is no longer required.

The other internal slot formwork is independent of the structure. It is assembled once the main structure is placed into position and recovered once the structure has moved to its next position.

These internal slots allow the creation of slots of the required dimensions.

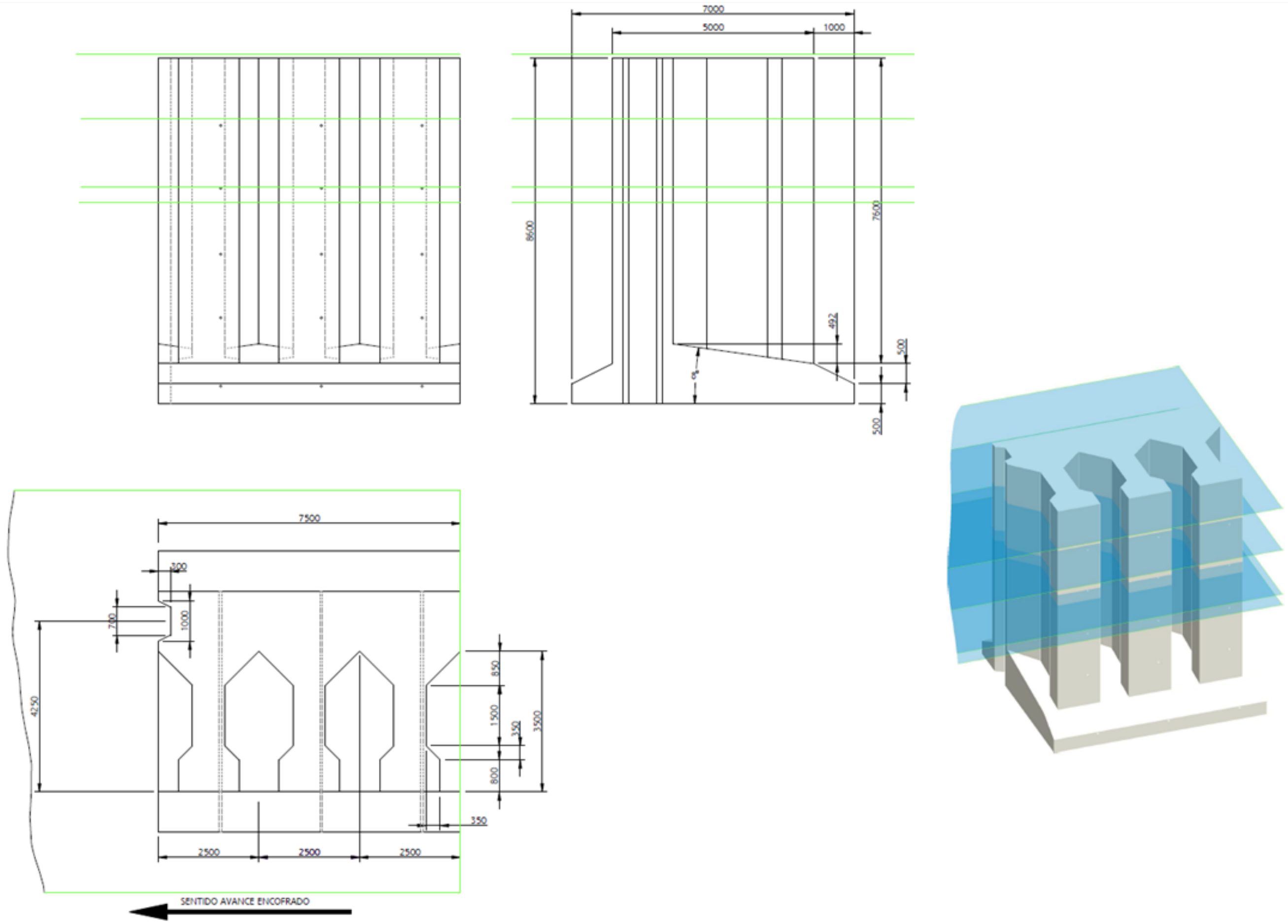


Figure 40: Section to be executed with Rubrica's Formwork. Detail of the internal slot openings for waves dissipation

CENTRAL INTERNAL SLOT

The main body of the central internal slot is divided into three parts. An inner panel that is articulated at the innermost vertex for the removal of formwork, and two side panels. These panels are screwed in 5 levels with horizontal beams.

The slot has a lower cover that is pressed against the main panels once in the concreting position to avoid overflowing of concrete inside the slots.

It is left loose during stripping to allow the panels to fold around the inside hinge without fouling it.

At the top, the slot formwork hangs from a platform that rests on the upper props of the main structure and allows the slot formwork to be positioned correctly.

The stripping of these panels is acheived by folding the internal slot formwork panels around its innermost edge.

To carry out this folding and subsequent opening of the internal slots, there is a connecting rod arrangement. A vertical profile is joined to the two side panels by means of articulated arms that go to each of the 5 horizontal beams of the side panels.

The vertical beam is additionally braced by cables to the beams of the panel to avoid a possible buckling effect.

The central slot formworks are attached to the side panel using DW15 bars.

To support the vertical thrust on the internal slot formwork there are two tying elements.

The upper chassis of the formwork is tied to the upper props in the central area of the slot at its widest part.

In the contact zone against the outer formwork there is a beam screwed to the top of the side panel that will act as a stop preventing vertical displacement of this panel.

To counteract the horizontal thrust of the concrete on the two side panels of the slot formwork there are vertical profiles that close against two other profiles welded on the outer formwork panel, thus also setting the position (opening) of the internal slot.

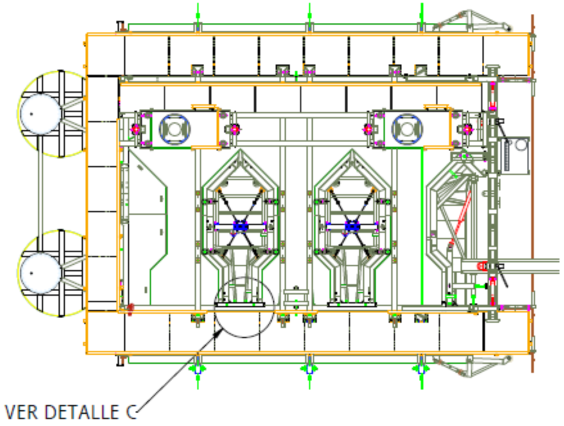


Figure 41: Plan view of the internal slot assembled in the main structure

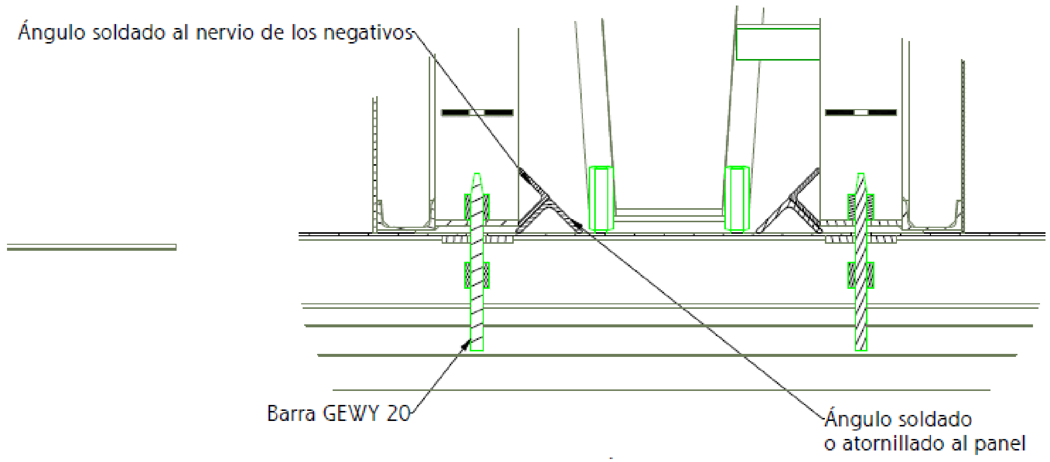


Figure 42: Vertical profiles welded in the internal slots and in the outer formwork to place the position of the internal slot and to counteract the horizontal thrust on it

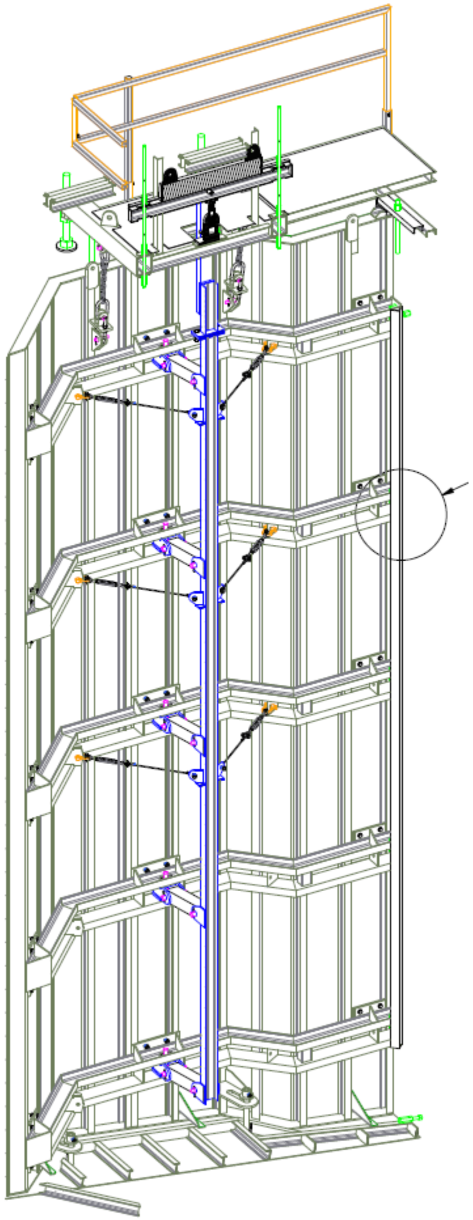


Figure 43: Inner view of a central internal slot

REAR INTERNAL SLOT

The formwork for creation of the rear slot is a half formwork of the central internal slot. This is fitted into the gap left on the front face of the previous segment.

In this element, both the horizontal and vertical pressures in the contact area against the exterior formwork are supported by the attaching elements of the internal slot to the side panel.

This tie is made by means of a series of DW15 bars with a machined coupler with a conical seat that acts as a pin absorbing both the vertical and horizontal thrust of the concrete.

Other elements that contribute to counteract the horizontal thrust of the concrete on the internal slot are the contact of the formwork panel itself against the segment in the inner vertex and a series of legs that hold the formwork against the previous section and against the lateral panel of the exterior formwork.

Finally, and to support the horizontal thrust in the inner part of the internal slot, its vertex is tied to a support bracket coming from the rear gantry that prevents this end of the internal slot from rising.

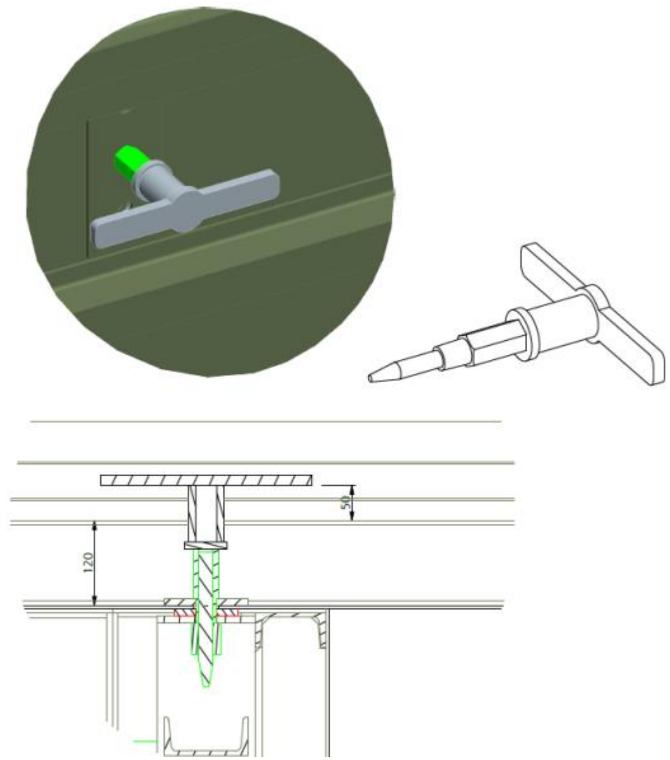


Figure 44: Fixing key of the rear internal slot to the outer panel that also constitutes the element to support the vertical and horizontal pressures on it

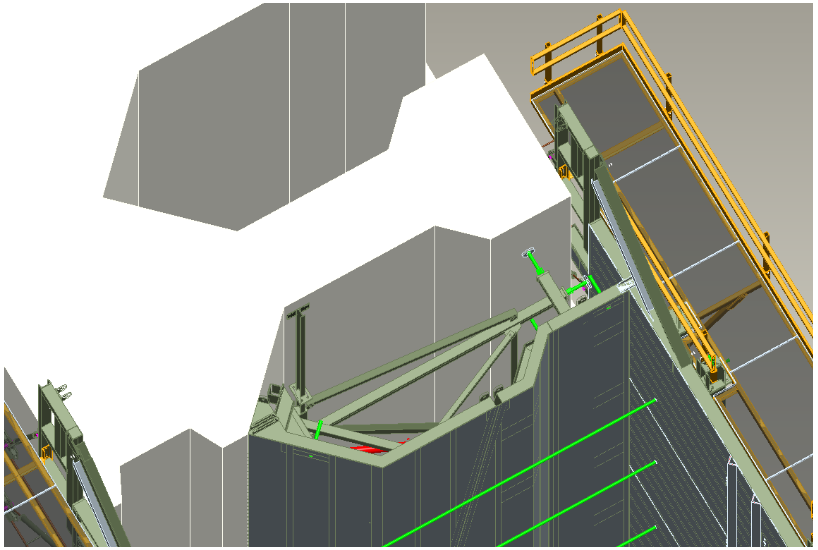


Figure 45: Rear internal slot showing the contact of the formwork panel against the previous segment done, in the inner vertex of the same, and a series of legs that hold the formwork against the previous element and against the lateral panel of the exterior formwork

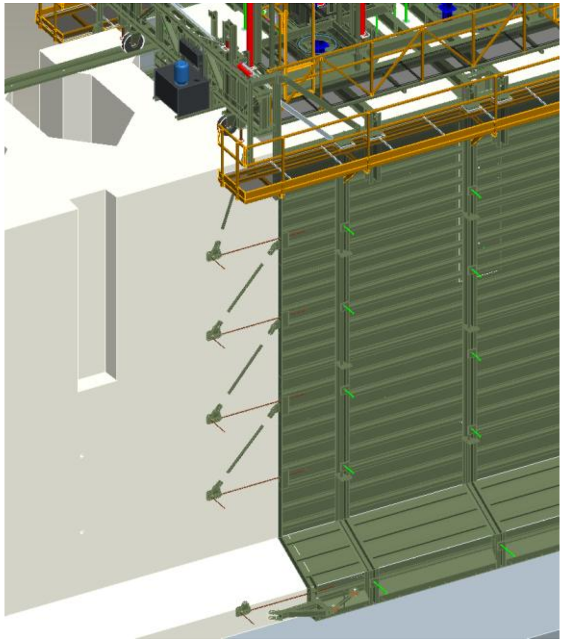


Figure 46: Anti-float tie-down system on the back of the equipment

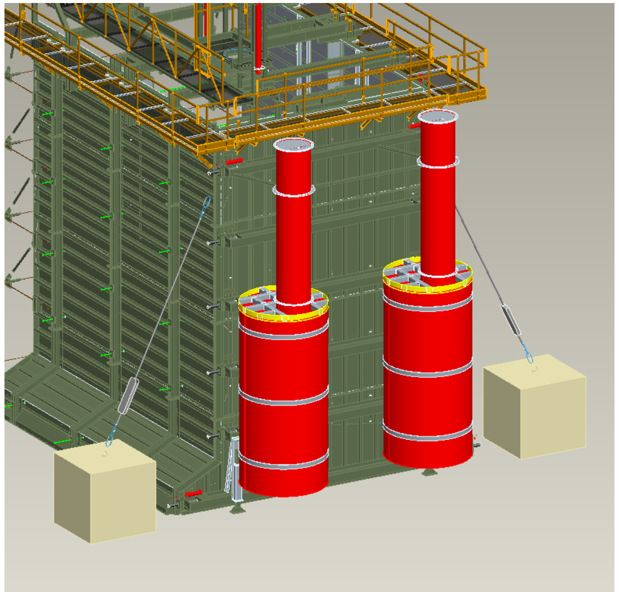


Figure 47: Counterweights to tie the front part of the structure thus avoiding floating at this point

7. ANTIFLOTATION SYSTEMS

To avoid the flotation of the equipment there are two basic elements:

1. The front part of the exterior formwork is tied to two 6tonne submerged counterweight concrete blocks by cables that must be tied before starting the concreting so that the formwork cannot rise.
2. The rear part of the structure is tied to the previous section by means of a horizontal and diagonal tying system. The horizontal anchoring counteracts the horizontal thrust of the concrete against the front panel while the diagonal braces are responsible for absorbing the vertical thrust in this part of the formwork.

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https://rubricaingenieria.com/en/rubrica-proyecto/underwater-formwork-sesimbra-port/

Figure 48: Rear view of the first segment cast

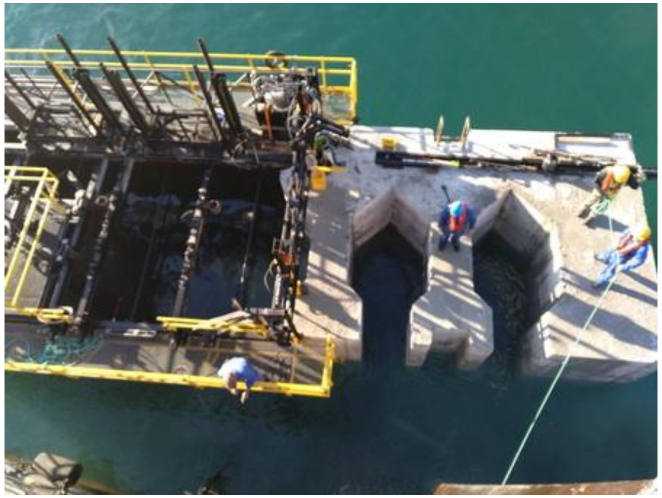

Figure 49: Upper view of the first segment cast.
Detail of the openings for dissipation of the waves

Figure 50: Outer formwork already advanced and settled for a new pouring

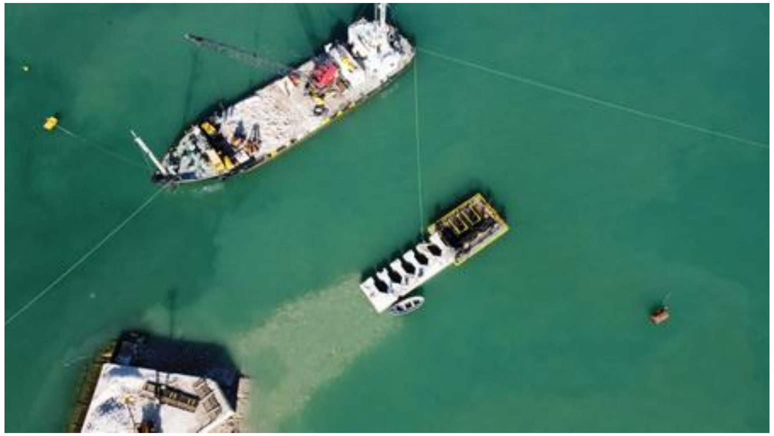

Figure 51: Aerial view of the formwork positioned for the execution of the third segment

← Figure 52: One of the central internal slots is hoisted to be positioned on the main structure

→ Figure 53: Outer formwork assembled on land prior to be launched into the water

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