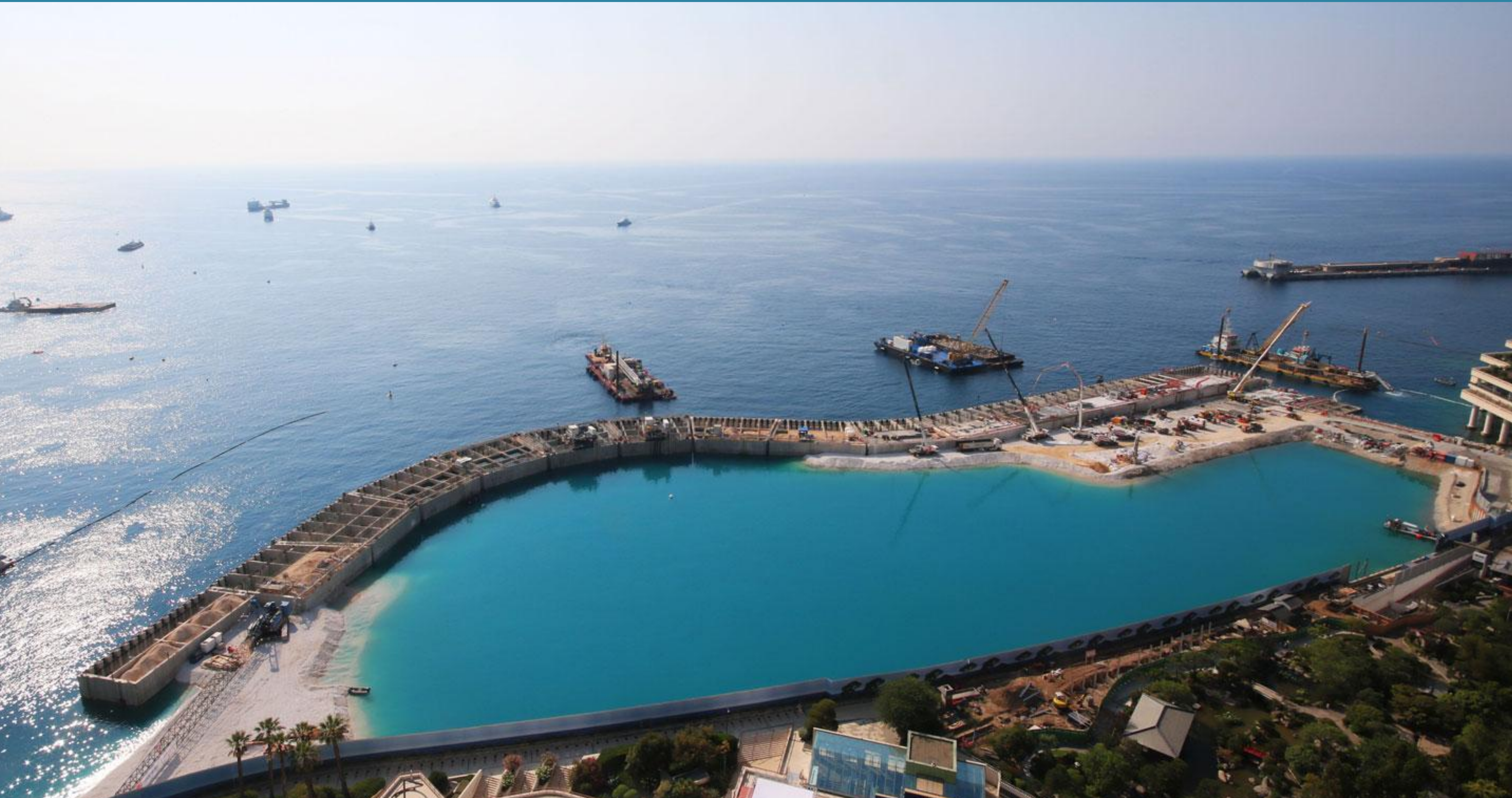
e-maritime

JUNE 2020 MONACO LAND PROJECTS



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Front Cover: Caisson belt forming the new land for Portier Cove Project in Monaco

Photo Credit: Bouygues TP Monaco

Back Cover: Towing a floating dock ´Marco Polo´ from Poland to Marseille

Photo Credit: Bouygues TP Monaco

International, online magazine about ports, docks, vessels and maritime equipment. Peer-reviewed.

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Dear Readers

This special issue is dedicated to Monaco Land Extension Projects with a special focus on its currently ongoing project of land creation for Portier Cove.

In the first article we provide an overview of two Monaco Projects: Port Hercules extension and Portier Cove.

The next article describes Design and Construction of Land Project for Portier Cove, caissons production, the caisson belt, backfilling and landfilling.

It is followed by drawings of caissons and of the belt.

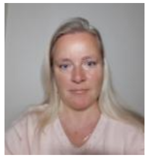
Last part of this issue brings information about the floating dock ´Marco Polo´ which was used for production of the caissons as well as about major vessels used for the project.

On the following pages, you can also find more information on both magazines (e-maritime and e-mosty) and also our Partnership offer.

My company has been affected by the current situation and as a result we have decided to extend the scope of services we provide. Our advertisement is on page 57. We hope that both our magazines (e-mosty and e-maritime) provide references of what we can do. We are happy to offer all our experience and knowledge and look forward to our possible cooperation.

Magdaléna Sobotková

Chief Editor



June 2020

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Thank you very much for cooperation on preparation of this special issue and also for allowing me to visit the construction site.

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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.

It can be read **free of charge** (open access) with possibility to subscribe.
The magazines stay **available on-line** on our website. It is also possible to download them as **pdf**.

The magazine brings **original articles about design, construction, operation and maintenance of vessels and maritime equipment, docks and ports from around the world**.

Its electronic form enables publishing of high-quality photos, videos, drawings, links, etc.
We aim to include all important and technical information and show the grace and beauty of the vessels and structures as well.

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e-mosty

The magazine e-mosty ("e-bridges") is an international, interactive, peer-reviewed magazine about bridges.
It is published on www.e-mosty.cz and can be read free of charge (open access) with possibility to subscribe.

It is published quarterly: 20 March, 20 June, 20 September and 20 December.
The magazines stay **available on-line** on our website. It is also possible to download them as **pdf**.

The magazine brings original articles about bridges and bridge engineers from around the world.
Its electronic form enables publishing of high-quality photos, videos, drawings, links, etc.
We aim to include **all important and technical information** and show the grace and beauty of the structures.

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

Our Editorial Board comprises bridge engineers and experts from the UK, US and Australia.

The readers are mainly bridge engineers, designers, constructors and managers of construction companies, university lecturers and students, or people who just love bridges.

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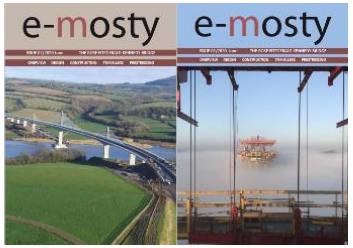

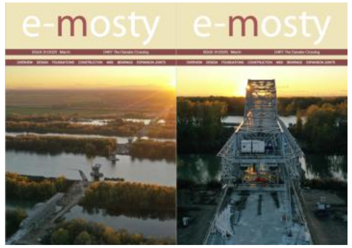

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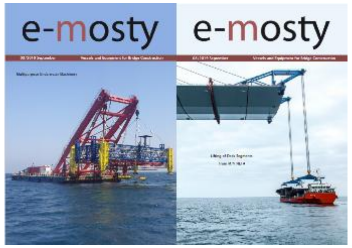

ISSN: E-MOSTY 2336-8179

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e-mosty

Bridge Design, Construction, Maintenance

e-maritime

Vessels, Ports, Docks, Maritime Equipment

The magazine e-mosty was established in April 2015. Its first issue was released on 20th June 2015 as a bilingual English – Czech magazine aimed mainly for Czech and Slovak bridge engineers.
Very quickly it reached an international readership.
In 2016 we extended the Editorial Board by two bridge experts from the UK, and since then four more colleagues – from the USA, Australia and The Netherlands – have joined us.
Since December 2016 the magazine has been published solely in English.
Each issue now has thousands of readers worldwide.
Many of our readers share the magazine in their companies and among their colleagues so the final number of readers is much higher.
Most importantly the readership covers our target segment – managers in construction companies, bridge designers and engineers, universities and other bridge related experts.

The magazine e-maritime was established in 2018 and its first issue was released on 30th March 2019.
The magazine is published in English. It is going to cover a vast range of topics related to vessels, maritime equipment, ports, docks, piers and jetties – their design, construction, operation and maintenance, and various maritime and construction related projects.
The Editorial Board already has two members – from the UK and the Netherlands.

Both magazines are with Open Access with possibility to subscribe (free of charge).
In January 2019 we established their own pages on LinkedIn with constantly increasing number of their followers. Number of subscribers of both magazines is also increasing.
We also know that the readers usually go back to older issues of both magazines.

MONACO LAND PROJECTS

Magdaléna Sobotková

INTRODUCTION

Monaco occupies approximately 2km² with a population of 39,000 people so land is very scarce. It is impossible to extend into France to enable economic development, for years the country has been adding to its total area by reclaiming from the sea.

Since the early 19th century, Monaco has gained an additional 0,4km². In the early 1960s, the Larvotto beach district was created, followed by the Fontvieille industrial area.

The latest project will form a new district, called Portier Cove, and will add an additional 0.06 km² (15 acres) of land.

In 2002 Port Hercules was extended to welcome larger cruise ships on one side, and to provide land for a new Yacht Club on the other.

Figure 1 shows the Monaco Land Projects since 1872.

We will shortly describe the Port Hercules extension and then focus on the Portier Cove Project.

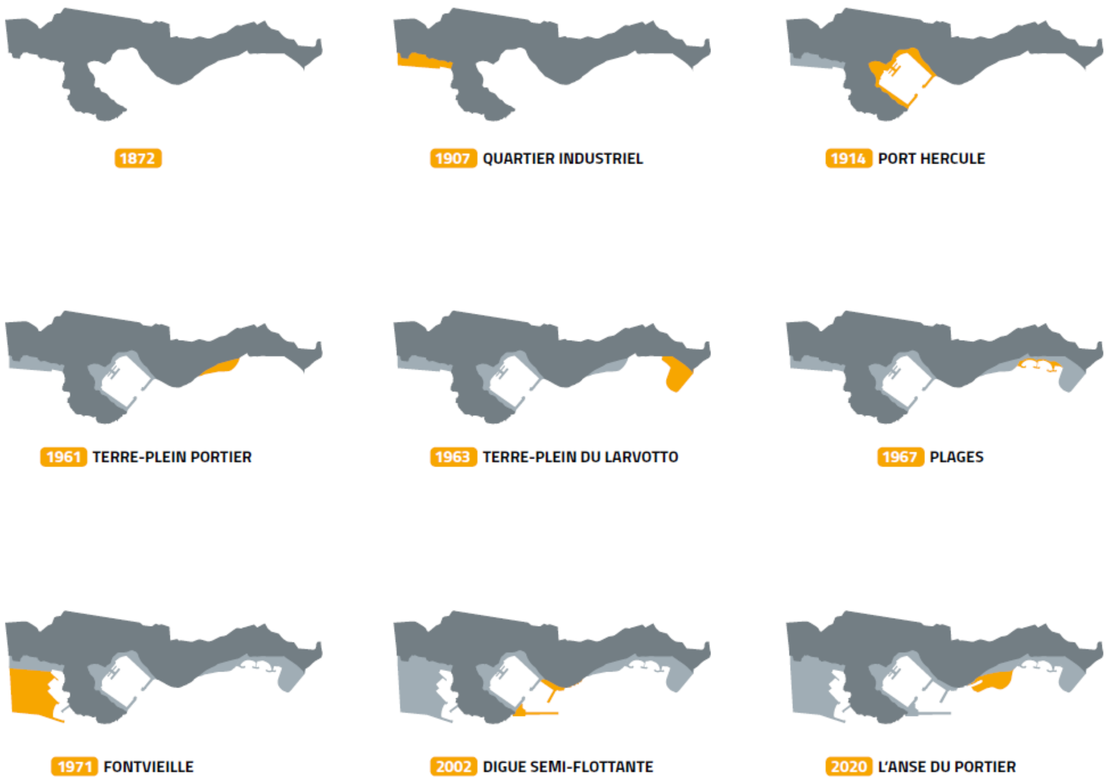

Figure 1: Monaco Land Projects

PORT HERCULES AND ITS EXTENSIONS

Port Hercules (Port Hercule la Condamine) has seen a series of extensions, fortifications, and upgrades.

In July 1901 construction of two quays in the harbour began, they still serve as the harbour's main walls. The solution adopted and realised in the years 1902 – 1914 was to build two 170m breakwaters on either side of the shore with a 100m channel between them.

It was the only possible way to provide shelter in the deep waters (between 20 and 50m) at the entrance of the harbour. The construction was constrained by the technology available at that time.

The modern shape of the port was completed in 1926, but it was not until the 1970's that major modernisation efforts began.

The Principality of Monaco then ordered further studies with the aim to improve the protection of the port.

In the early 90's the Hercules Port extension project was conceived with the aim to welcome larger cruise ships on one side, and to provide land for a new Yacht Club on the other.

The Principality of Monaco thus decided to extent the port which proved to be necessary for several reasons:

- To protect the harbour from large waves created by easterly winds during high tides;
- To reclaim land from the sea for real estate and other developments;
- To increase the marina capacity to receive additional pleasure boats and create an outer harbour specifically for cruise ships.

PROJECT OVERVIEW	
Client	Principality of Monaco
Contractor	Doris Engineering
Implementation dates	October 1999 – April 2003
Hydraulic Backfill	400,000m^3
Dredging	130,000m^3
Reinforced concrete	41,000m^3

↖ *Figure 2: Aerial View of Port Hercules*

Photo Credit: Lebunetel Architects

The implementation required adequate studies of coastal topography, sea bottom morphology, wave climate and meteorology.

It was decided to construct a backfilled platform, a semi-floating breakwater and a counter-jetty.

The structures were prefabricated and then towed to Monaco to mitigate nuisance caused by a construction site on an urban seafront and to secure protection of the marine environment.

<u>The project consisted of:</u>

1) The construction of a one-hectare backfilled platform at the foot of Fort Antoine.

   After preliminary dredging works the platform was built from backfill underwater foundations were consolidated by vibro-flotation and grouting and then fitted with six caissons.

   These concrete caissons, with a height of 10, 20 and 30m and weighing between 15,000 and 35,000tonne, were built using steel-reinforced panels and formwork. The caissons were made in La Ciotat in France and towed to Monaco.

2) The construction of a semi-floating breakwater, attached to the embankment by a metal ball-and-socket joint.

   It is 28m wide on top and 44m at the bottom, 352.5m long, with displacement of 160,000 tonne and 16m draught.

   This concrete structure was built in Algeciras, Spain by Dragados and FCC Construccion, and towed to Monaco after 12 days of navigation.

   Its primary function is to protect the waters of the outer port and the port itself as well as to provide docking facilities for cruise ships on both the port and sea sides.

   It is connected to the platform through the abutment caisson to which it is attached by a large metal fabrication. It allows for movement of up to 5° in any direction.

   The sea side end is fastened by two sets of anchors fixed at a depth of more than 55m.

   The anchoring system comprises eight mooring heavy chains (five are 500m long and three are 100m long) next to the harbour entrance, and two supplementary chains 200m long towards the open sea and 150m to the land side.

   The anchors to which the chains are connected are formed by steel piles driven up to 29m into the sea bed.

   The breakwater has at its base two 8m wide wings for stabilisation to support a 44m long underwater mooring – they provide counter rolling and pitching.

   The structure is 3m above water level on the port side and 6.6m above on the sea side.

   The internal space of the caisson was designed to provide 360 parking spaces on four levels and a dry storage for 25,000m^2 on two levels.

   The outer harbour is protected through the “fixed seawall” technique.

   This uses Jardine Posts on the sea side of the caisson to create a partially enclosed space which waves enter and which absorbs their energy.

3) A transition structure between the breakwater and the coast; and

4) A prefabricated counter-jetty supporting the ends of the structure. Length 145m, width 30m, draught 9m.

   The land side is on an abutment and the sea side in a supporting caisson set of a riprap foundation.

   It shelters the outer port and provides an additional basin for large pleasure boats.

   It is a fixed structure with a prestressed concrete caisson 2m above water level.

   The jetty, caisson and the abutment were also built in La Ciotat, France and towed to Monaco.

The extended port welcomed the first cruise vessel in April 2003.

The extension of Port Hercules has helped develop the number of leisure berths; (700 instead of 300 berths, of which 110 are reserved for vessels measuring between 20 and 100m) and enabled the berthing of larger cruise ships.

This has developed the urban landscape and economy of the Condamine neighbourhood and remodelled the coast.

It also provides necessary protection for the port. Now the port is one of the rare deep-water ports on the Côte d'Azur.

This feature makes it a natural choice for receiving large yachts.

That is why the construction drew on specific techniques which took the marine environment into consideration and which were developed and patented in the Principality.

The extension was done in 1999 – 2003. The main part – putting in place the counter jetty and the floating breakwater – was completed in September 2002.

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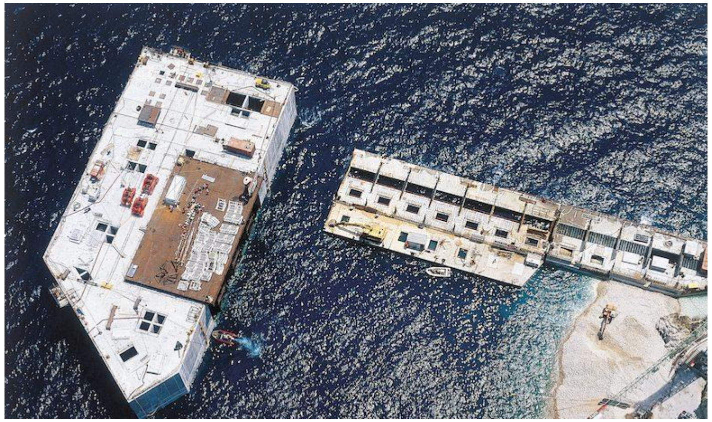
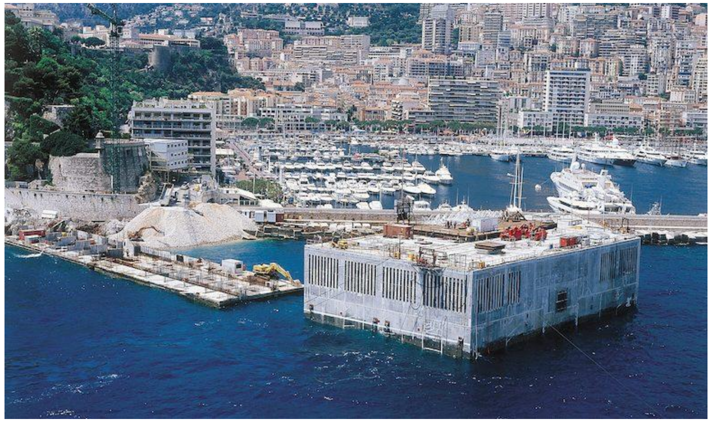
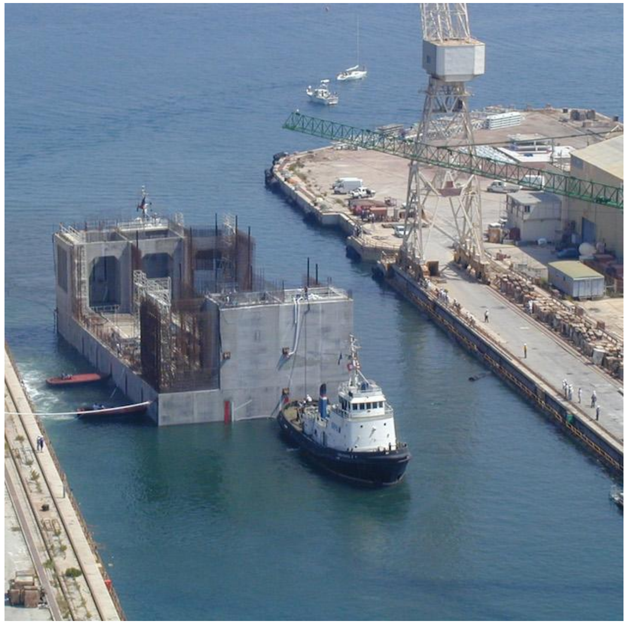
PHOTOS FROM THE CONSTRUCTION







Figures3 - 8: Hercules Port Extension. Photos Credit: Vinci

MONACO LAND PROJECT

Portier Cove, Monaco's new eco-district in the eastern part of Monaco, is designed as an extension of the Principality's existing coastline from the Grimaldi Forum to the Formula One tunnel, see Figure 1.

The new district will provide further 60,000m^2 of land.

It will offer a solely pedestrianised surface with many elements:

- One hectare public park;
- Various public walkways, both along the coast and throughout the district, which will connect with existing areas of the Principality;
- A port offering approximately 30 berths;
- An underground public car park;
- Buildings offering both office and retail space;
- Luxury housing including multi-tenant buildings and private waterfront villas;
- An extension of the Grimaldi Forum (convention centre)

Portier Cove has been designed to integrate with the existing coastline of the Principality both aesthetically and environmentally.

The realisation of this project is an architectural and technical challenge. It responds to the Principality's ambitious energy transition objectives regarding its commitments to reduce greenhouse gas emissions (becoming carbon neutral by 2050) and to the need for growth in a dynamic and modern country.

Part of the challenge is to design and apply construction methods which minimise the impact on the natural environment in agreement with Monaco's global sustainable development project.

The developed areas must make it possible to build a district at the forefront of a new responsible urban energy management, and of new construction methods whose constant objective is to reduce the impact on the environment.

Architects are at the heart of this process. Valode and Pistre Architects and Renzo PianoBuilding Workshop are the two internationally renowned firms that coordinate the work of design teams to bring together design, aesthetics, energy efficiency and sustainable development. Associated with landscape architect Michel Desvigne, they introduce a natural space within this artificial extension.

The northerly extension belongs conceptually to the land (Architects VPA), the southerly extension (RPBW – Renzo Piano Workshop) belongs to the sea with its new small harbour and the building at the seaside perched on the new waterfront quay as a ship in a dry dock.

The appearance of the building perched above alludes to a vessel, but articulated and fragmented as if still emerging from a shipyard.

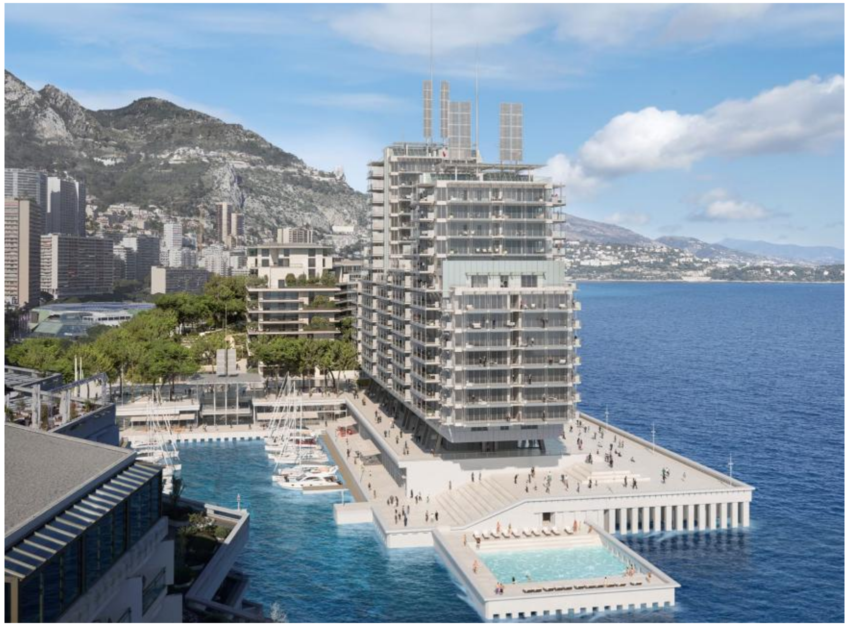
This 60m high building of up to 18 floors consists of 47 luxury apartments. The total net area of the building is 33,500m^2, including the apartments and terraces.

The project will be built at estimated 2 billion EUR and will be finalized in 2025.

Figure 9: Location of the Portier Cove Project. Source: google maps

Figures10 - 12: Project Visualisations

↓ Photos Credit: Valode et Pistre



PROJECT STAKEHOLDERS

The Concession Agreement for the Monaco Land project was signed on July 30, 2015.

The Principality of Monaco entrusted SAM (Société Anonyme Monégasque) L'Anse du Portier as the developer of the project with the mission to design and build the new eco-district of the Principality of Monaco; to extend the land onto the sea, to fully finance the project, and to manage the commercial and residential real estate.

The Mission URBAMER, attached to the Department (Ministry) of Equipment, Environment and Urban Planning, was created to pilot the project on behalf of the Monegasque State and monitor the successive phases of the project, particularly in the area of sustainable development.

SAM L'Anse du Portier has appointed Bouygues Travaux Publics MC to design and construct the platform, known as the "maritime infrastructure".

Building of structures on this reclaimed land has been delegated to SAM des Aménagements du Portier and to SAM des Superstructures du Portier, as contractors for the public and private works.

The related construction works are entrusted by these contractors to Bouygues Travaux Publics MC and various Monegasque companies.

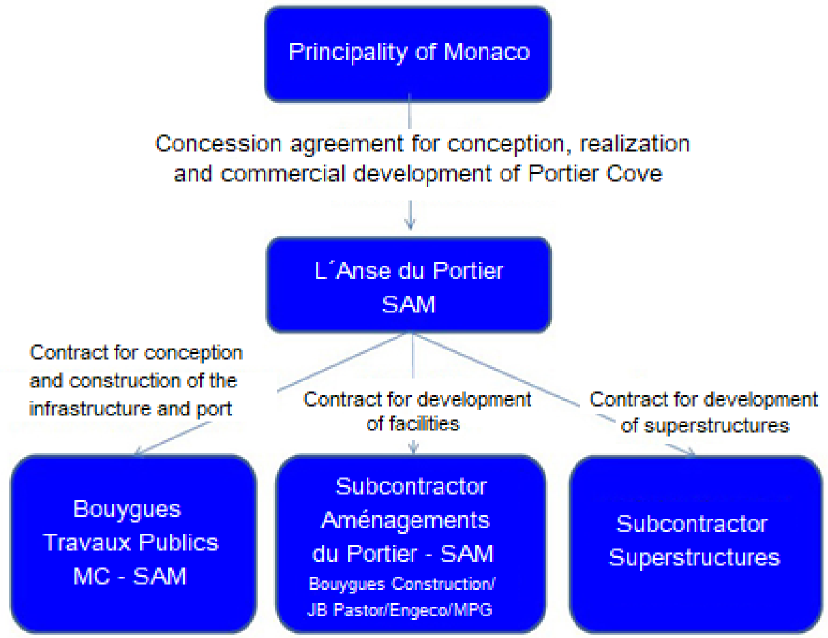


Figure 13: Project Organisation Chart

ENVIRONMENTAL ISSUES

Monaco's coastline on the Mediterranean is already a fragile and vulnerable environment. Any further land reclamation projects threaten to disturb or damage the coastal ecosystem.

Monaco's leaders have approached the prospect of further land reclamation with caution and have stated that new projects would have to meet strict environmental standards to limit damage to flora and wildlife.

The Extension at Sea of the Anse du Portier is located in a marine ecosystem rich in biodiversity.

All people and companies involved in the project are fully aware of the services provided by biological diversification, which is essential to the sustainable development of Monaco's territory.

The eco-neighborhood project is a BiodiverCity-certified achievement because of the commitment to ensure that ecosystems function effectively by implementing best practices in environmental and species conservation.

In order to measure the impacts of the Sea Extension, monitoring and evaluation plans have been drawn up with precise instructions to ensure the effectiveness of the environmental measures put in place (sedimentation, fish stocking, precautions to be taken with respect to hydrocarbons and turbidity, the Larvotto herbarium, prohibition of any direct discharge into the natural environment, etc.).

ECO-DISTRICT

The Anse du Portier Project will be the first Monegasque eco-district. Obtaining the environmental certification «HQE Aménagement» will crown the ecological commitment of the terrestrial part of the project.

Priority will go to soft mobility: it will be exclusively pedestrian and will accommodate 4 bicycle stations (including 2 electric).

From an energy point of view, 40% of the ecodistrict's conventional consumption will be of renewable origin, 80% of which will be dedicated to the hot and cold water supply network and 80% for street lighting.

Finally, collective housing will be certified «BREEAM Excellent», thus defining the standard and environmental ambition of the project.

WATER QUALITY

Reflecting its adherence to the "Low Impact Construction Site Charter", Bouygues TP Monaco carries out numerous environmental verifications to ensure that the Maritime Extension at the Anse du Portier is carried out with utmost respect for the environment and the population.

In cooperation with the Environment Directorate of Monaco, vigilant monitoring of the quality of bathing water is carried out three times a week from April to October.

This multi-weekly inspection is supplemented by laboratory analyses to ensure the excellent quality of the Principality's water during the construction works.

Very careful monitoring of water turbidity is carried out by 6 sentinel buoys equipped with sensors. They are deployed around the construction site, in the marine reserves of Larvotto and Spélugues.

This comprehensive monitoring system enables Bouygues TP Monaco to capture the parameters in real time and to be notified by an automatic alarm system in the event of a variation in water colour.

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MONACO LAND EXTENSION - CAISSON BELT AND LANDFILLING - DESIGN AND CONSTRUCTION

Jacques Resplendino, Technical Director, S.A.M. J.B. PASTOR et Fils
(until December 2019 Technical Director, Bouygues Travaux Public)

INTRODUCTION

The Project involves extension of Monaco land into the sea between the Grimaldi Forum, the Formula One tunnel and the Larvotto exhaust chamber.

Land extension comprises the caisson belt and subsequent landfilling. The caisson belt is formed by 18 caissons of which 17 create the belt and one will be used for a swimming pool. The caissons numbered C02 – C16 are of a trapezoidal shape, the caissons C00 and C01 are rectangular.

The caissons are not identical, however, the typical measures of a caisson are: height 25m, length 29m, width 27m. The caissons have a reinforced concrete base and Jardin-type posts which serve as breakwaters.

This article looks into design and construction of the caisson belt, creation of the land accompanied with drawings of the caissons and the belt.

It also includes the specification of major vessels and equipment used for the construction.

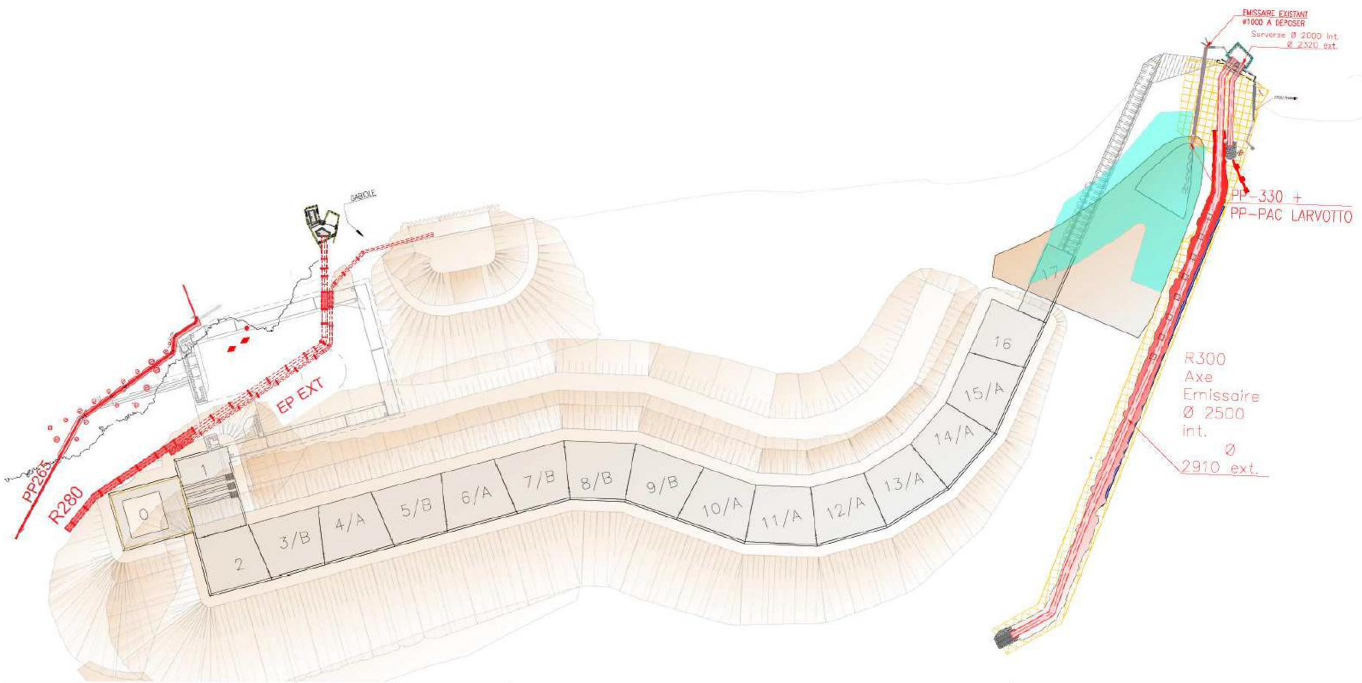


Figure 1: Scheme of the caisson belt with indicated Larvotto exhaust chamber (on the right)

CONSTRUCTION

LARVOTTO RAIN WATER EXHAUST CHAMBER

The works commenced in spring 2017 with the arrival of a vibro compaction shovel which placed the sheet piles for the future rain water exhaust chamber of the Larvotto.

The chamber will be more than 350m^3 and is aimed to collect and exhaust the rain water through a 300m long outlet pipeline.

DREDGING OPERATIONS

In April 2017 the Anse du Portier rock wall, a 65m long and 20m wide pier resting on stilts, was removed by ´Mimar Sinan´, a backhoe dredger.

At the same time, a ship with dynamic positioning system, a split hopper barge ´Tiger´, arrived at the site.

Approximately 3,500tonne of rockfill was moved to allow for the dredging of polluted and non-polluted sediments.

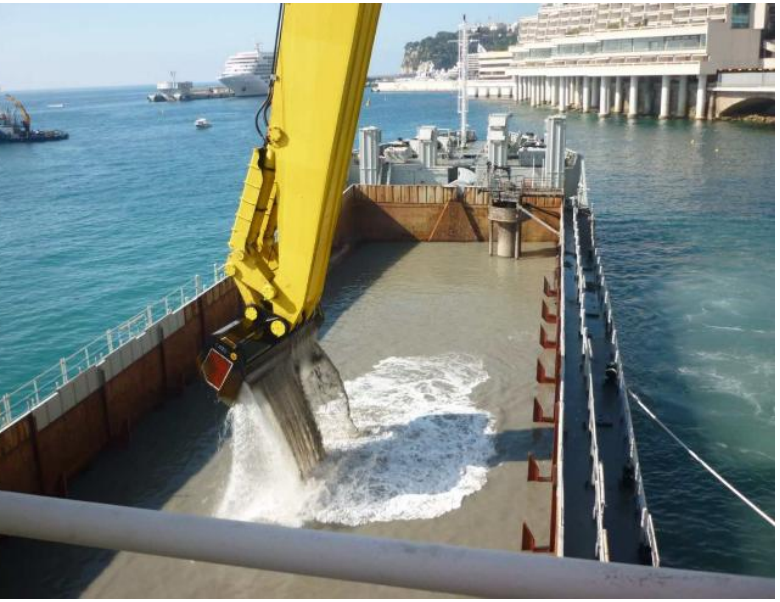
The polluted sediments (silt unfit for this type of construction) of 600,000m^3 from areas more than 30m deep were extracted by ´Tiger´.

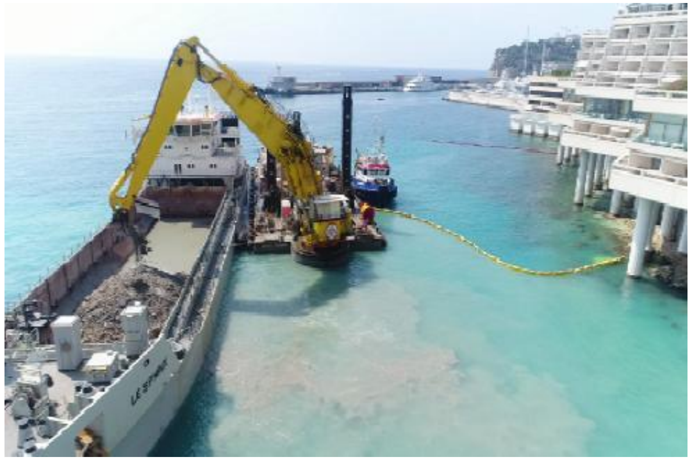
Dredging of polluted mud in areas less than 30m deep was carried out by the backhoe excavator situated on the piled pontoon ´Mimar Sinan´, and using the ´Etoile´ and ´Sphinx´ Split barges.

The objective was to expose the rocky part of the seabed which forms the base for the construction site.

The polluted sediments were temporarily stored in the Envisan eco-materials processing centre in Toulon for further treatment.

To prevent adverse effects on the surrounding marine environment, a system for turbidity monitoring and for marine mammal detection was set up so that the operation procedure could be modified as necessary.





Figures 2 and 3: Dredging of the sediments with ´Mimar Sinan´

Figure 4: Dredging with ´Francis Beaufort´

The non-polluted sediments of 350,000m^3 were removed to about 50m depth by a computer controlled vacuum onboard a trailing suction hopper dredger ´Francis Beaufort´.

It stored the sediments in its 11,000m^3 tank before carefully submerging it offshore, 2.5 nautical miles from the coast, to a selected disposal site 200m deep, where studies demonstrated the absence of environmental impact on the flora and fauna.

SEABED PREPARATION FOR CAISSON BELT

After the dredging was complete, it was necessary to prepare the surface of the underwater backfill on which the caisson belt was later set.

Backfilling operations began by ´Simon Stevin', a fall pipe rock installation vessel. It used a robotic conduit to place 1.5 million tonnes of rock.

The rock had been very carefully prepared at the Chateauneuf-les-Martigues quarry in southern France and was loaded at Fos-sur-Mer.

Figure 5: ´Simon Stevin´

The rocks were measured to specific sizes and cleaned multiple times to decrease any risk of turbidity during subsequent unloading on site.

For several months the FPV ´Simon Stevin´ went back and forth from Fos-sur-Mer to the Principality of Monaco on average every three days, since loading took about 20hours (30,000tonne per trip), followed by a 15-16hours voyage and 20hours for unloading.

To limit turbidity, the FPV did not unload the rocks at the surface but as close as possible to the seabed, which varies between a depth of 15 - 45m. It used a tube made up of several sections and placed the material in highly precise horizontal movements thanks to dynamic positioning.

As the cassion C17 on the Larvotto side is shallower than the others, it was necessary to raise the bedding backfill on this section. It was done with the barge ´Tow1´.

Compacting most of the 1.5 million tonnes of bedding for the 18 caissons was done by an 80m long barge equipped with two large cranes together with a barge ´JD1´ which also took part in the vibroflotation operations with various tasks including making stone columns.

The vessels ´Simon Stevin´and ´Fabio Duo´ left the Monaco waters after having undertaken backfilling operations, having laid 5/50 materials and rocks removal.

The rock breaking process was done by a barge ´Francesca´.

VIBROFLOTATION

After completion of the bedding works for the caissons, soil treatment and compaction by vibroflotation began by two vibrating needles (40tonnes) lifted by two cranes (500tonnes each) onboard of a barge ´NP460´.

The cranes covered all necessary areas also taking into account the effects of the weather.

In order to limit subsidence and prevent the bedding materials from moving during the process, vibroflotation started at the bottom edges of the banks of bedding materials and then moved upwards towards the zones where the caissons were going to be placed.

The principal tool for this process is a needle delivering the vibrations to compact the soil.

It consists of: a lifting head, a head for cable connections, extension tubes, an electric vibrator and a system for injecting air/water.

Two variants were used depending on the depth to be reached:

- Up to 15m = 1 probe of 28m
- Over 15m = 1 probe of 43m

To create a vibroflotation point, there is a specific process which breaks down into three phases, see Figure 7 below:

- Positioning the probe
- Sinking the probe into the soil
- Compaction of the soil

A GPS antenna was placed under the vibrating needle to allow the operator to identify the areas which already had been treated and which had still to be done.

A colour coded mapping system was used for this purpose, see Figure 8.

Figure 6: The vibroflotation barge ´NP 460´ with two cranes

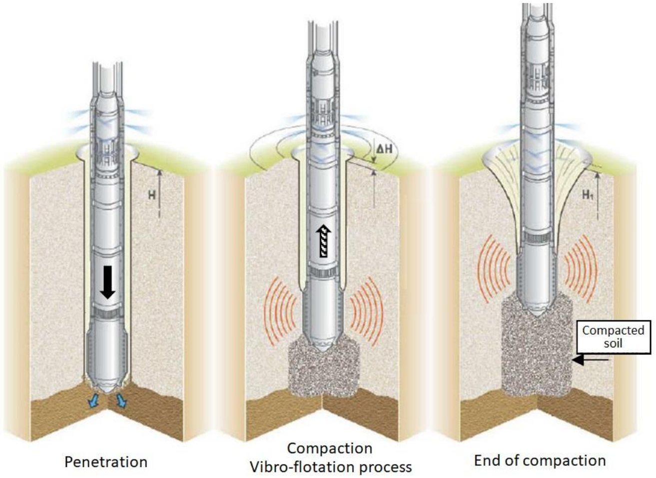


Figure 7: Vibroflotation process

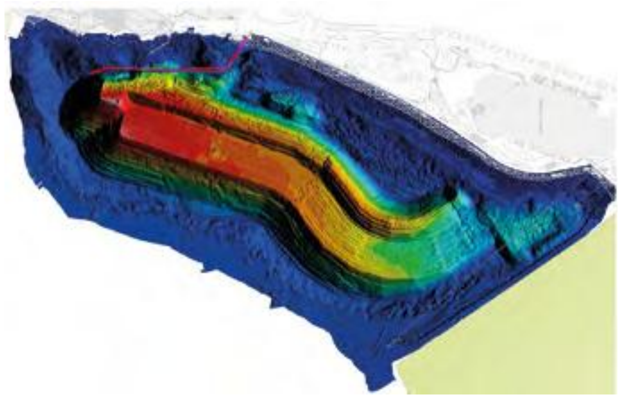


Figure 8: Coloured coded mapping system

Compaction took place after a number of passages of the probe and depended on the level to which the probe was raised, the period of time at each point and the threshold amperage of the vibrator (70cm in 30/40 seconds).

The effect of vibration was to settle and compact the surrounding material, leading to a crater forming at the surface of the vibroflotation point.

FLATTENING AND LEVELLING

Two phases followed, flattening and levelling. To ensure the absolute stability of the caissons and the whole future land surface, there had to be a firm, well-compacted and as far as possible a smooth base.

The flattening process served to treat the rough terrain along the surface of the bedding material. It meant roughly flattening the top of the backfill to a depth of -20m.

A grab bucket moved the aggregate from the top of the bumps to the troughs.

At the end of the operation, the differences on the surface were less than 20cm.

After that, the levelling equipment could operate and level the terrain accurately.

The levelling phase was necessary for the final adjustment layer (finish) to give the best possible surface on which to place the caissons.

The levelling equipment is a 54tonne, 30m by 15m metal structure, placed on the backfill and equipped with a large 15m wide horizontal blade.

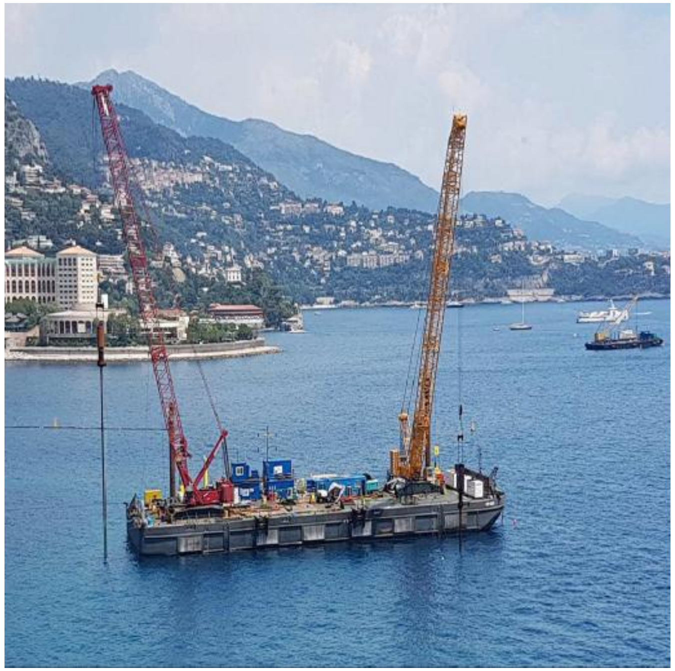
Fine aggregate, 20/40mm in size, was placed in front of this blade, which then 'scalped' the surface, making it flat and level to within a 5cm tolerance.

For this work, four divers checked the progress of the blade and the functioning of the leveller.

It took six days to level the base area for one caisson.

Once the surface was prepared, the caissons could be installed.

Another barge named ´Edmond´ started installing the anchorage points at the final positioning for the first C02 caisson.



↖ *Figure 9: Vibro Compaction*

↑ *Figure 10: Levelling Equipment*

PORT OF MARSEILLE

Manufacturing the caissons required a specific site with a 22m draft, ease of access, and realistic proximity to Monaco where the caissons were delivered post manufacturing.

The City of Marseille and the Le Grand Port Maritime de Marseille (GPMM) in Bouches du Rhône, France were found to be the best suited options for this large industrial project.

And, thus, in late 2016 and early 2017, Bouygues TP began preparing the port site for the caisson construction.

While construction of the foundation in Monaco was underway, works began in the Port to manufacture 18 concrete reinforced caissons for the caisson belt which constitutes the protective and structural perimeter of the Portier Cove district.

Figure 11: Caissons stored in Marseille ready for towing

CONSTRUCTION SITES

Two main sites were necessary.

First, 10,000m^2 on the quay to prepare the caisson manufacturing (reinforcement, assembly of the framework), and secondly, 32,000m^2 on the sea dike where the floating dock ´Marco Polo´ operated and where the caissons were stored before transporting to Monaco.

Sites also had to be prepared for multiple administrative offices, more than 700 hundred workers, the building platforms, delivery and storage of the construction materials, and assembly and access to the floating dock.

Authorisations and permits were issued; the floating dock complied with the requirements of ICPE, which is the French acronym for “facilities classified for environmental protection”.

Figure 12: Plan of construction and storage sites in Marseille Port


Figures 13 – 14: ´Marco Polo´ - at sea, towing from Poland to Marseille

Figure 15: Pouring concrete into a caisson

Figure 16: Float-out of a caisson

FLOATING DOCK ´MARCO POLO´

Each caisson was constructed individually in a floating dock named ´Marco Polo´. It is a large, floating metal structure weighing 4,559tonne, 56m high and 50m wide.

The floating dock was designed and built in Poland for Bouygues TP and transported to Marseille by sea.

The floating dock was built specifically for this unique project.

However, the designers kept in mind the standards set by the Principality to reuse and recycle materials and thus the floating dock will be converted by Bouygues TP after this project and will be used to manufacture wind turbines in the future.

(More information on the floating dock ´Marco Polo´ please find in Part 3 "Vessels and Equipment Used for Monaco Land Project").

CAISSON CONSTRUCTION

Each caisson weighs approx. 10,000tonne and stands 27m high and 28m wide, using 3,800m^3 of concrete.

The construction site as a whole mobilized 700 people, the caisson construction required continuous work of 120 people working 24/7 in three eight-hour shifts Monday through to Thursday and two twelve-hour shifts Friday to Sunday.

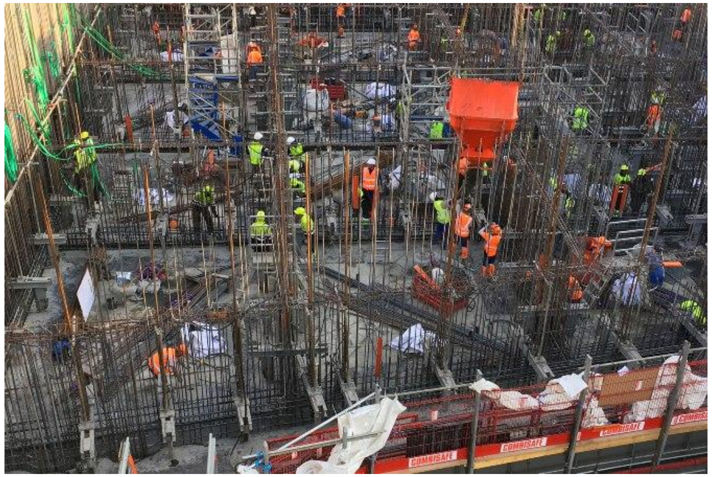
It took 20 – 22 days to produce each caisson and eighteen months to produce all caissons.

The caissons were constructed as follows:

- **Phase 1:** Construction of the raft, 700m^2 and 0.8m thick, inside a dry caissonnier, using 600m^3 of concrete.
- **Phase 2:** Construction of the walls which create cavities inside the caisson.

  The walls are 280m in length, from end to end. They were constructed continuously, using a slipforming technique, with an average progress of 12cm per hour until a height of 27m was reached on the rear wall of the caisson.
- **Phase 3:** Construction of "Jarlan" type concrete posts (breakwater for dissipating wave energy). Having removed the formwork, 2 – 3 weeks were needed to construct the Jarlan posts and a further 1 – 2 weeks to finish fully equipping the caisson.

Concrete was cast into each caisson, increasing the weight of the total caisson – floating dock structure and slowly sinking it.



Figures 17 and 18: Caisson Production

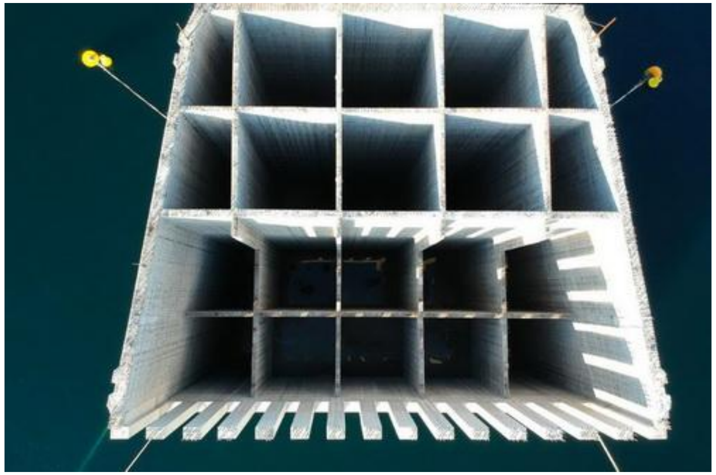


Figure 19: Top View of completed caisson

Once the required height was reached, the floating dock was ballasted and submerged into water until the caisson was released and was afloat.

Once the caisson was afloat, it was towed to a dock area a few hundred meters away and a second phase of concrete work started to create the part of the caisson that will be visible from the sea, ensuring the best architectural aesthetic.

While the second phase of work was completed on the caisson, the floating dock was reinstated and work began to cast the next caisson.

- **Phase 4:** The completed caisson was stored before being prepared for towing to Monaco by sea.

JARLAN-TYPE BREAKWATERS

Jarlan-type breakwaters are an effective solution both for reducing the energy of wave swell and the noise pollution generated by vertical structures facing the sea.

The 18 concrete caissons making up the belt constitute a 500m long vertical wall looking out to sea.

Day after day and particularly when the weather is bad, waves will be breaking against these concrete walls with potentially undesirable consequences.

As the waves rush into the numerous cavities, they break up inside and a large proportion of the energy is dissipated, an effect multiplied by the ingenious design and precise execution of the Jarlan breakwater system.

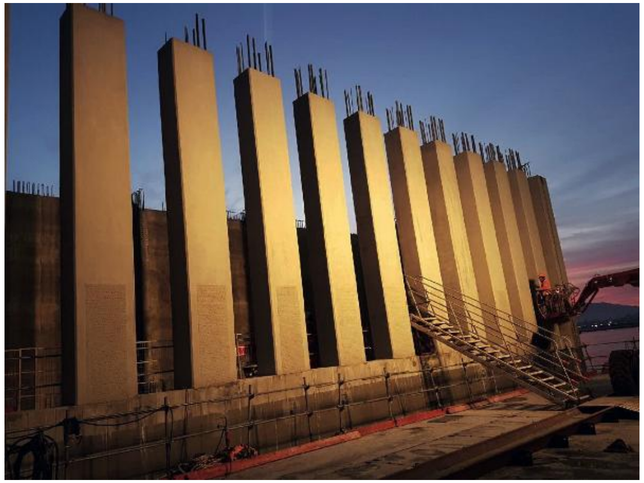
It is all the more efficient since waves flowing into the hollow caissons break up against the solid back wall into thousands of little droplets which then mix with the air to form a kind of emulsion, which in turn acts as a shock-absorbing cushion for the following wave.

Furthermore, the Jarlan breakwaters absorb much of the noise generated by the breaking waves. The noise made by breaking waves can be quite loud.

The structure itself will be continuously under pressure, with implications for durability and expected serviceability.

↑ *Figure 20: Reinforcement for casting posts for Jarlan-type breakwaters of the caissons*

↗ *Figure 21: Completed posts*



There are also navigation considerations for shipping since the structure is close to a port with hundreds of arrivals and departures of big cruise ships every year.

And lastly the flora and fauna obviously could not develop normally on caissons forming closed structures.

It had therefore been decided to create hollow concrete caissons, equipped with Jarlan breakwater posts with a cross-section of 1m.

The type of concrete used offers the same durability as that of the overall structure, but for aesthetic reasons considerable care was required to ensure that the sections above sea level also look attractive.

In this context several studies were undertaken, and in 2015 a particular colour was identified as being the most appropriate for such a project.

These breakwaters extend 4m above and below sea level, and also serve to promote the development of a marine ecosystem.

In the cavities going from sea level down to 4m specific habitats to encourage flora and fauna development were installed.

Figures 22 and 23: Concrete shelters and sacks with sand for marine animals

CONCRETE

The concrete used is composed of specific properties, depending on its end use. For this project, the concrete must withstand the permanent aggression of sea salt and remain unaffected by chloride ions that erode materials.

The concrete was tested and adapted specifically to guarantee the durability of this project's construction.

The concrete, as with all materials used, was tested daily to ensure it met the standards set. The concrete hardening also needed to be monitored daily as the weather conditions affect its properties.

The method in which the caissons were constructed layer by layer in the caissonnier proved a unique challenge when considering all of these elements.

The outer surfaces of the caissons are treated with specific materials that favour the acclimitisation of living species.

Artificial seagrass, rocky areas and cavities were installed on the sides of the caissons to aid the regrowth of the natural habitat.

The generators used to power the caisson manufacturing were equipped with particulate filters to limit air emissions, DeNOX modules were in place to retain the release of nitric oxide, and the oils used to lubricate the floating dock framework and to coat the caissons to delay the corrosion effects of sea salt were composed of plant or synthetic elements to limit any impact of toxins to the marine environment.

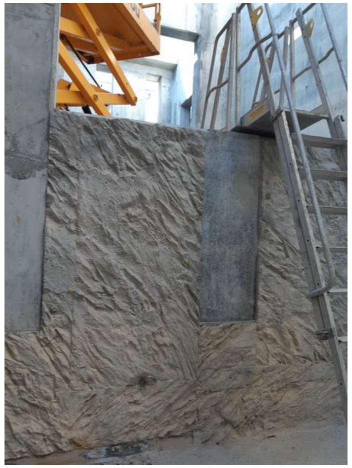
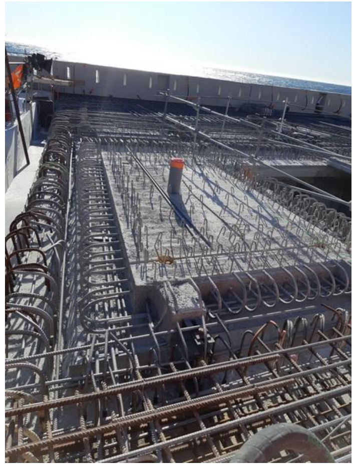
DOCK BLOCKS

After completion of all 18 caissons, ´Marco Polo´ left the port. In early May 2019, in Marseille Port works started on the casting of 80 dock blocks designed to link up the caisson belt, and the road link on the Larvotto side.

The blocks have average dimensions of 8m x 2m and they are 1.2m high, each weighing about 50tonnes each.

Their installation started in late August 2019 and will finish in September 2020.

Pre-cast slabs that act as formwork close to the caissons on the upper side of the Jarlan Chambers are also made in the Port of Marseille.

Figures 24 and 25: Special surface treatment inside a caisson for marine animals


Figures 26 and 27: Precast slabs and dock blocks

TOWING THE CAISSONS

DEFINING THE CONDITIONS OF TRANSPORT FOR AN UNUSUAL STRUCTURE

Trapezoidal in shape, measuring up to 28m wide and 27m high and weighing 10,000tonne, the caisson is neither a ship nor a hydrodynamic object.

By its shape, size and weight it was a challenge for towing between the manufacturing site in Marseille, and the immersion site in Monaco.

Additionaly the caisson cannot be easily towed in water; it also does not meet any towing standards.

Eighteen months of preparation were necessary to complete this operation in order to define and validate the method and the means implemented.

It was necessary to work on the basis of existing nomenclature for towing large objects.

Thus, a long qualification phase began at the end of 2016 to establish the conditions for towing a caisson.

The consensus reached between the companies involved in the construction project, the companies in charge of towing and public authorities and insurers, made it possible to define the operations and the normative framework that took into account transport safety for workers, the equipment, for each caisson and for other vessels.

Once established, the towing conditions were validated from an administrative and insurance point of view.

The calculation of the towing requirements was based on:

- *The number and power of tugboats needed:*

  It was decided to do the towing with a single 89tonne Bollard Pull capacity tugboat.

  The vessel chosen was ´VB Fos´ as she complied with the requirements for the vessel: she can be mobilised throughout the whole year which was necessary for the transfer of all the caissons from Marseille to Monaco.

- *The configuration of the towing:*

  The towing was done by means of a wire rope that measured 57mm in diameter which could also extend over 800m.

  It was the maximum distance that could separate the tugboat from the caisson.

- *The rigging of the caisson.*
- *Conditions of the currents and weather criteria for navigation.*

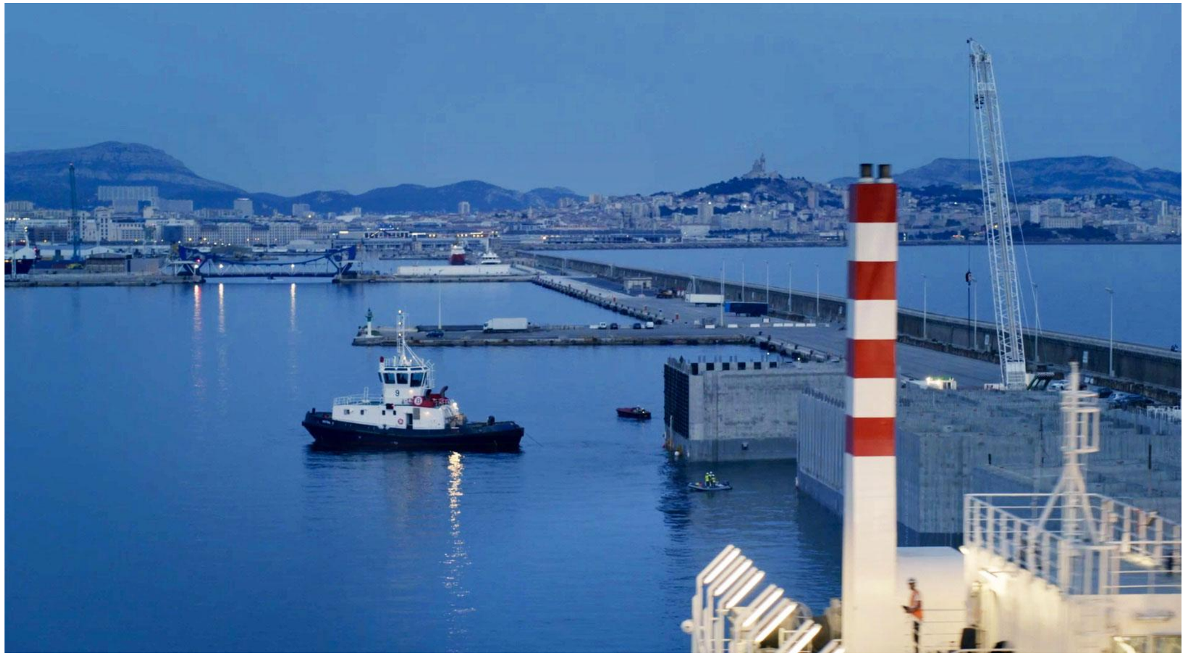


Figure 28: The first caisson leaving the Port of Marseille

TOWING A CAISSON BETWEEN MARSEILLE AND MONACO

PREPARATORY WORKS

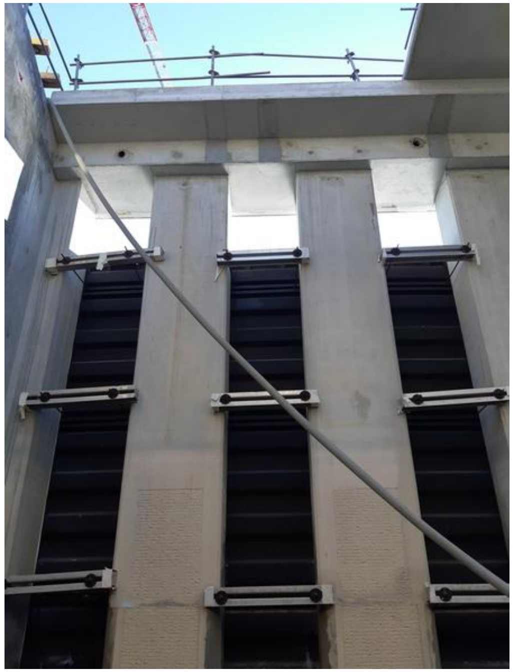
For transportation of the caissons at sea the openings between the posts were closed with 900kg shutters and sealed with resin.

This way the caissons were protected against water ingress during towing.

Before departure leak tests were carried out.

After immersion and setting of the caissons on their place, the resin was removed manually.

For the towing operation, the cable was unwound from a winch on the ´VB Fos´, attached to the caisson by means of plates sealed on the caisson and a bridle.



Figures 29 - 31: Openings between the posts with shutters

The attachment system was also installed on the opposite side of the caisson for safety reasons. In case there was a problem with the initial attachment points, the tugboat could use this backup solution.

In Marseille, one working day was required for installation of the entire connection between the tugboat and the caisson.

TOWING

The navigation between Marseille and Monaco lasted three days, at a speed of 1.5knots.

The purpose of this low speed was to limit the forces generated by the caisson’s fluid resistance, but above all to perfectly control the momentum of the caisson and the speed generated by the tugboat.

The very precise timing allowed for the rapid execution of all operations and limited the risks associated with changing weather conditions.

The weather conditions for the entire manoeuvre were therefore essential to ensure the success of each crossing and the installation of each caisson in its final position.

The teams in charge of this phase (transport and installation) worked closely with Météo-France and had a specific access to its services and precise information to establish their routing.

Throughout the navigation route between Marseille and Monaco, seven shelter sites had been defined to cope with sudden weather changes or extremely localised climatic phenomena.

If the appropriate weather conditions were not met, the crossing was cancelled.

Apart from that, a clear route had to be assured throughout the transfer.

The maritime authority defined the points on the route of the ´VB Fos´ for each crossing by a decree. It marked out one nautical mile around the convoy in which no one could enter.

As with any towing, which in this case took place day and night, specific markings and signals indicated the presence of the sea convoy.

Upon arrival in Monaco, the caissons were immersed immediately, during the day.

Figure 32: Caisson Towing by VB Fos

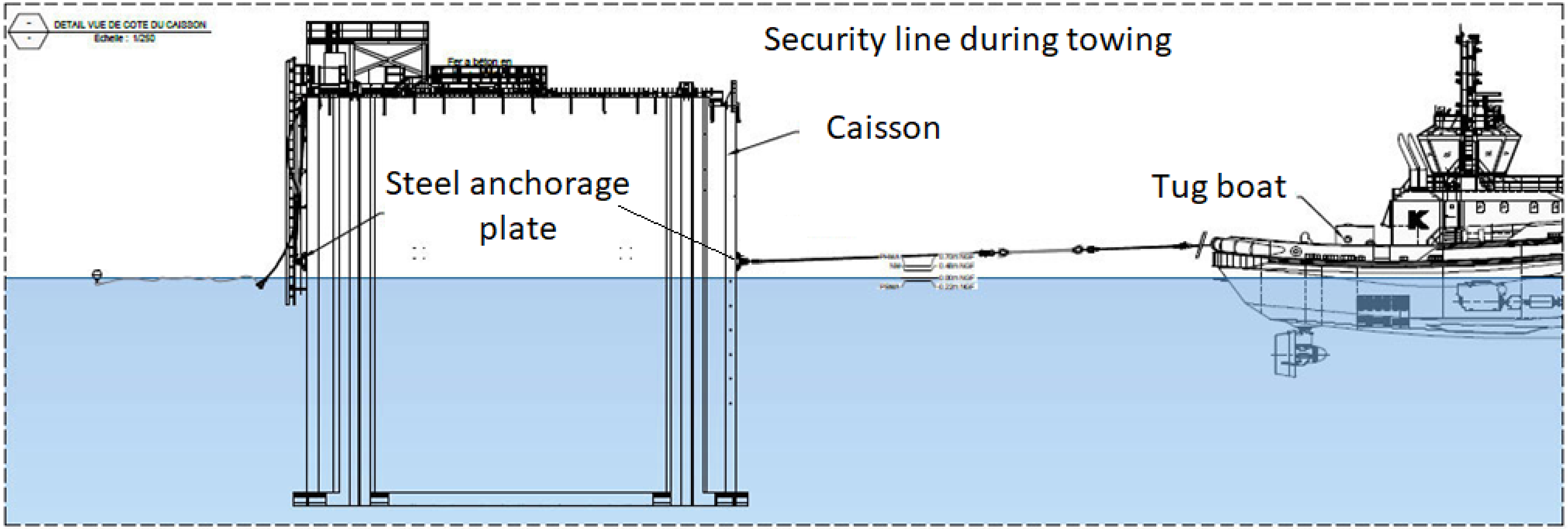


Figure 33: Configuration of towing a caisson Photo © Eiffage Infrastructures

CAISSON INSTALLATION

The approach manoeuvre to the designated location was carried out with two multicat vessels placed at the front and rear of the caisson.

These ships have azimuthal propellers that rotate 360°.

They are therefore extremely manoeuvrable, which allowed the position of the caisson to be manually adjusted, and offered both stability and manoeuvrability.

This was decisive for adjusting its exact position with centimetre accuracy.

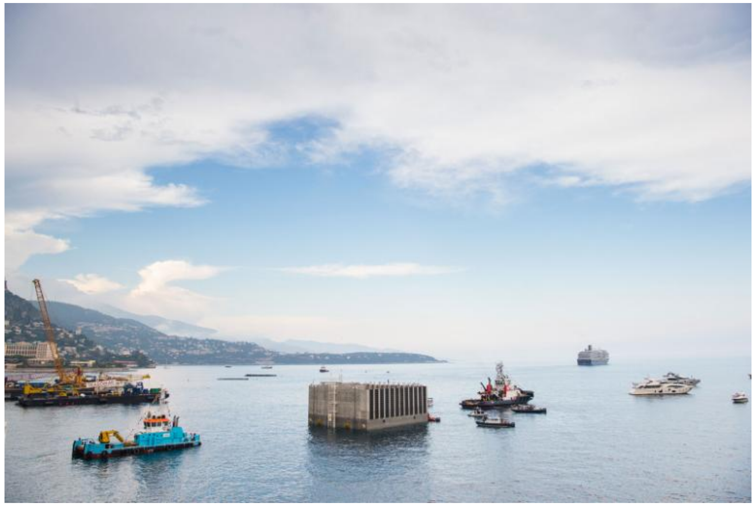
At this stage, the caisson underwent its first ballasting to bring it less than one metre above the backfill.

The final installation was managed by six hydraulic winches placed on the caisson.

Six people were on board to deploy six cables all around the caisson to be immersed, which was then docked next to the caisson already installed.

The caisson was equipped with topographic monitoring equipment.

The topographical manager read the data and gives, in real time, the position of the caisson to the operations manager who moved it by managing the tension of the cables.



Figures 34 – 36: The first of 18 caissons to arrive in Monaco was inaugurated by HSH Prince Albert II. During the ceremony, the first caisson was blessed by the Archbishop of Monaco, Monsignor Bernard Barsi, and the ceremony was attended by Martin Bouygues, the CEO of Bouygues TP which is the company responsible for construction on the project.

Once the caisson was definitively stabilised, balanced 50cm above its final position, it was completely ballasted to make it descend onto the backfill.

In case the target and actual positions were not aligned, the ballast water was discharged from the caisson to make it float and the operation was resumed.

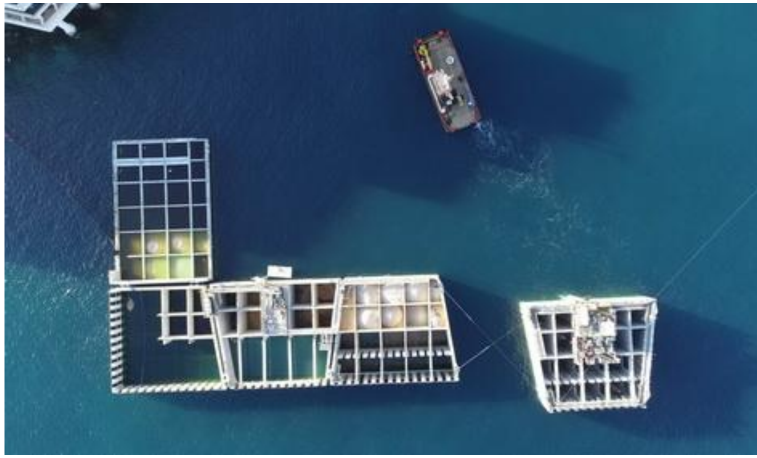
When the installation was validated, solid ballasting started - the water was replaced by 0/20 grain sand to make the caisson even more stable.

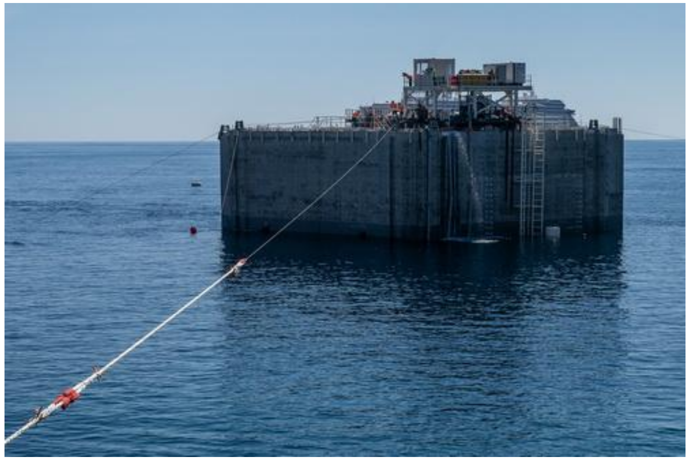
To limit the risk of turbidity, the water was pumped out as the solid ballasting progressed, respecting settling times to discharge clear water into the sea.

After this operation, the final weight of the caisson is about 24,000tonne.

The first caisson, marked as C02, was completed in Marseille at the beginning of November 2017 and was delivered to Monaco in late June 2018.

The caissons were transported to Monaco and immersed one-by-one. The entire caisson belt was installed over a one-year period and completed in July 2019.





Figures 37 and 38: Caisson C02, specifications: nearly 10,000tonne weight of which 1,580tonne ballast, 13.9m draught, 3,265m^3 of concrete, 950tonne of steel, overall height 25.2m, length 29.3m, width 27.3m.

↖ Towing ↗ Immersion

↑ Figures 39 and 40: Caisson 05 approaching the site

CAISSON C00 FOR THE SWIMMING POOL

The last caisson which was installed near the Faimont hotel will serve as the glazed swimming pool.

This caisson is of different design: it is rectangular, 15m high and it features 7 openings each measuring 3.5m x 1.0m, 11cm thick.

The openings are set with steel frames and acrylic panels to give the swimmers the impression of swimming through a natural seascape.

The acrylic panels are designed to withstand pressures and are built to handle the 1:100year wave.

The caisson will feature levelled seating, service rooms and other modules to accommodate a swimming pool of 14 x 20m, 2m deep.

↑ *Figure 41: Visualisation of the swimming pool*

Figures 42 and 43: Caisson C00 for the swimming pool

June 2020

BACKFILLING AND LANDFILLING

In July 2019, the caisson belt installation was completed, and the perimeter of the new Portier Cove eco-district created a new coastline of the Principality of Monaco.

BACKFILLING OF CAISSONS

Once the caissons were positioned, they were solid-ballasted.

Their initial mass of 10,000tonne was thus increased and stability was guaranteed on the bedding backfill.

In order to ensure the integrity of the platform in case of severe storms or major maritime assaults, certain measures were taken.

Riprap was used to complement and protect the “caisson bedding backfill” of the whole external part, while backfill for the technical platform was positioned at the back of the caissons.

Earthmoving machines (excavators, loaders and dumpers) were used every day to flatten it.

This process was extended by the vibrocompacting of all the backfill for the technical platform. 420,000m^3 of sand from Piombino in Italy filled the platform; it was transported in around 11 round trips by the 223m long dredger ´Leiv Eiriksson´.

The backfill for the technical platform acts as a restraint to maintain the caissons.

Much of the stability of the platform depends on it.

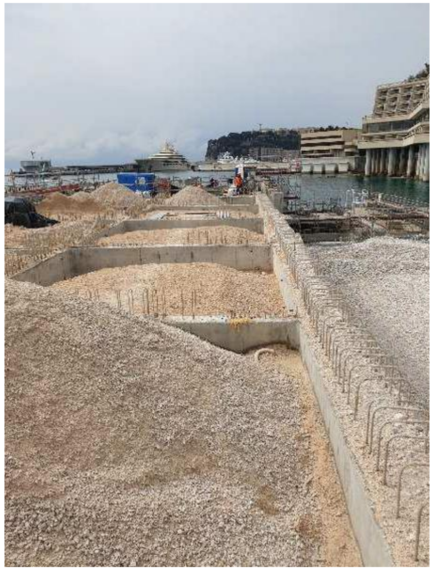
Deposited at the back of the caissons, the backfill for the technical platform forms a strip that is 500m long, 9.50m wide and exceeds the water level by 1.75m.

It consists of 20/180type quarry material of 340,000tonne from the Le Revest-les-Eaux quarry (Var, France).

It was transported by two ships, ´Rhine´and ´Daniel Bernoulli´, the latter being a highly accurate dynamic positioning vessel, capable of self-unloading.

Other ships involved in ballasting the caissons were ´Tertnes´and ´Omvac8´.

To create the rock shell and to protect the caisson´s bedding backfill, blocks of 0.3 to 1tonne were transported by ´Larnaca´ and unloaded on the site.



Figures 44 – 46: Ballasting the caissons and the belt

Figures 47 - 49: Backfilling with ´Stornes´

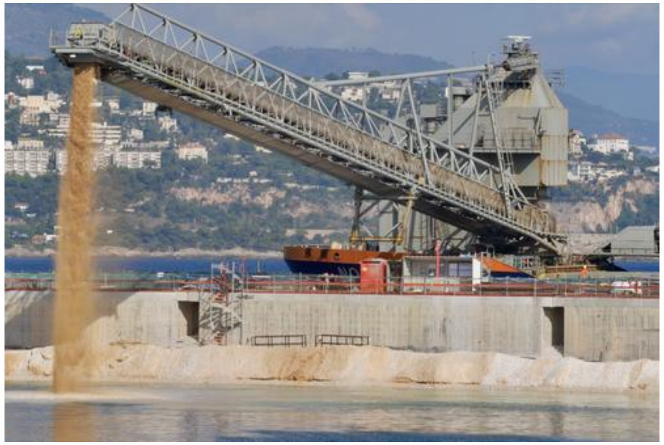
LANDFILLING AND CREATION OF LAND

The closure of the caisson belt created a salt water basin between the existing and the developing coastlines.

To create the land, sand was gradually deposited in the 'lake'. For this operation, two vessels - ´Nordnes´and Stornes´ - ensured four deliveries of sand per week, two per ship.

24,000 tonne were deposited at each passing.

In total, over 30 deliveries were required to transport the 750,000tonne.



Figures 50 and 51: Ballasting the caissons and backfilling with ´Nordnes´

Figure 52: Aerial View of the caisson belt

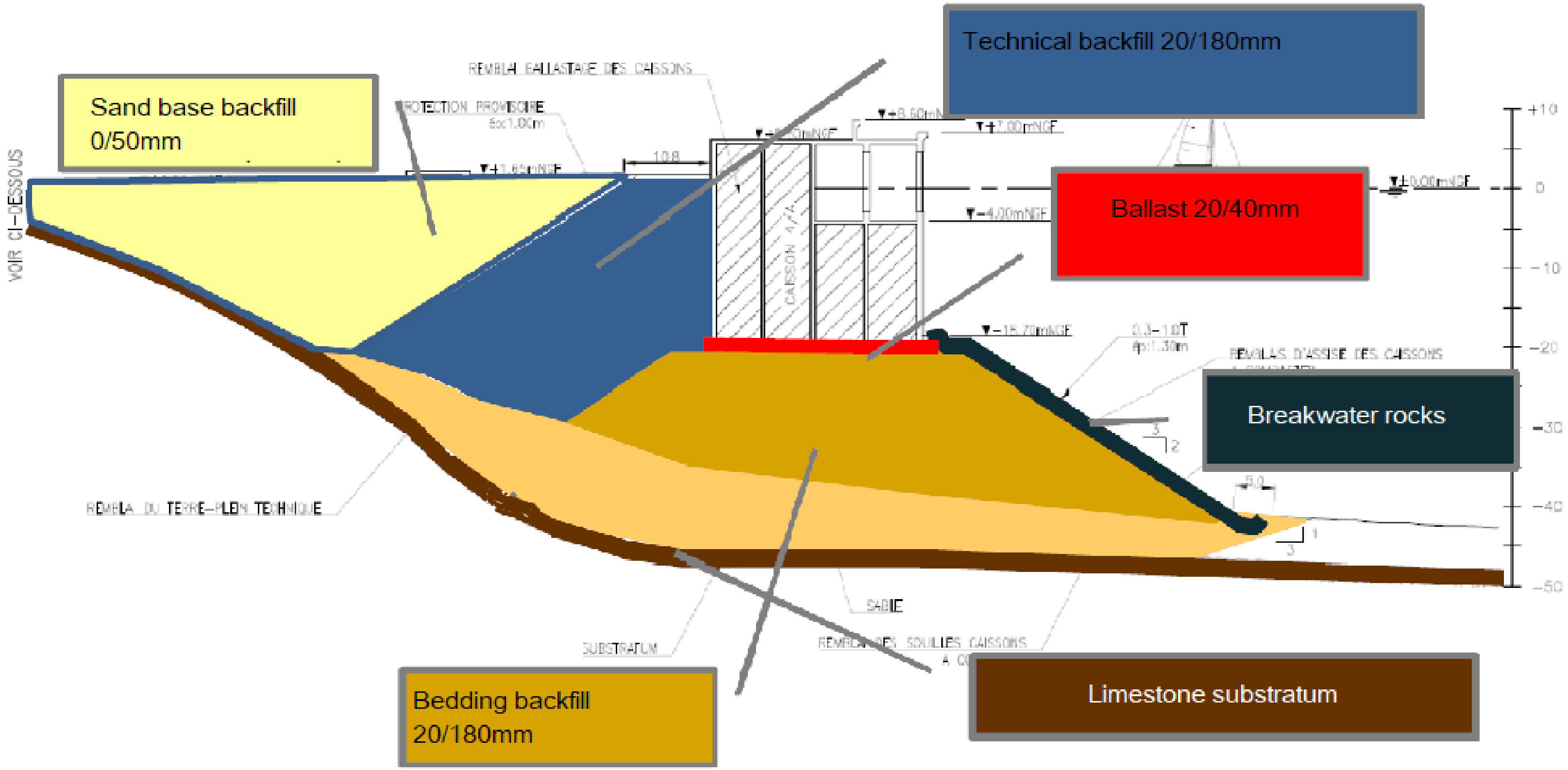


Figure 53: Schematical cross-section indicating individual layers of the backfill and setting of the caisson (C04)

Each ship is equipped with a 75metre long unloading facility - the grasshopper - which is a mobile and tilting elevator, equipped with a conveyor belt (or buckets depending on the use), which allows the deposit of materials.

Each ship was placed parallel to the caissons in a predetermined area, see Figure 54.

The grasshopper passed over the concrete structure to unload its cargo at the rear. An unloading took about 14hours.

While the quarry sand was deposited, the body of water was emptied by percolation.

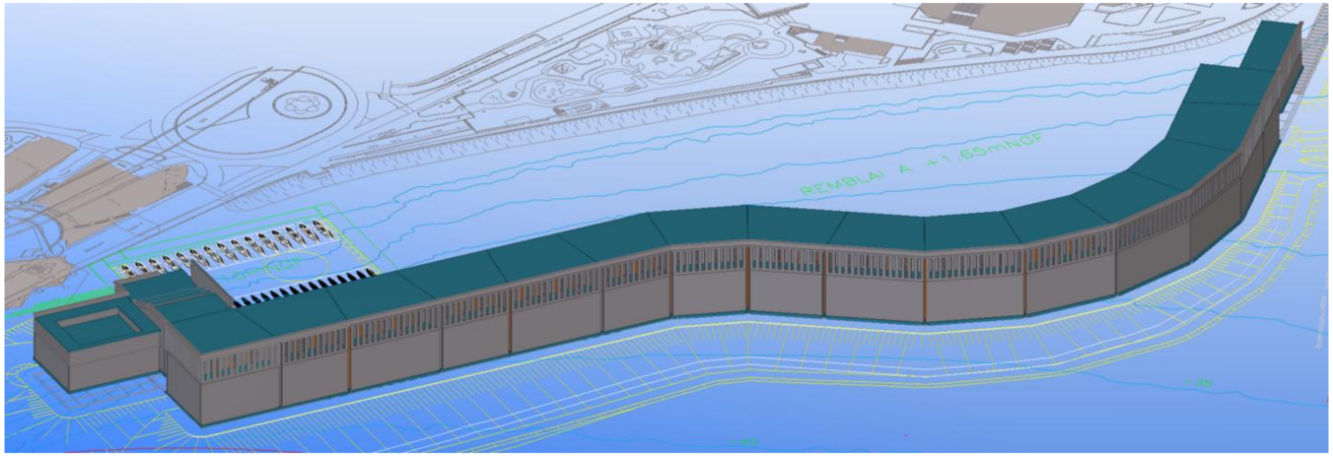


Figure 55: 3D Plan of the caisson belt

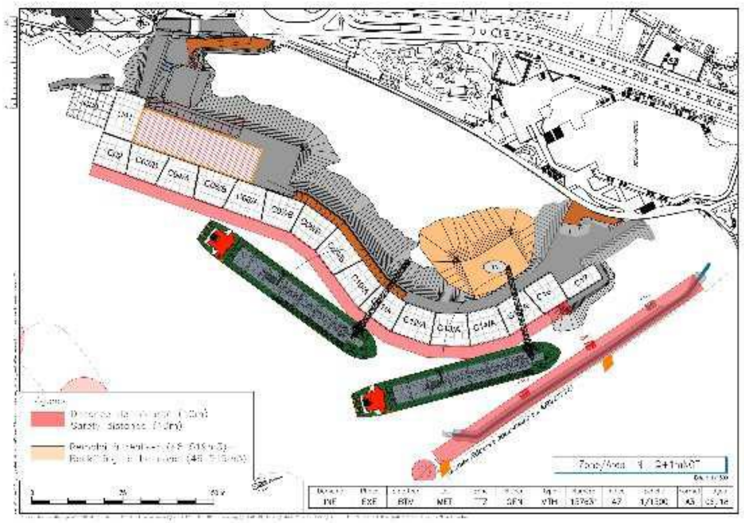


Figure 54: Ship positioning

Sea water slowly escaped through the underwater backfill and flowed out to the open sea outside of the caisson belt, at the same time as the sand was deposited.

The advantage of this process was that the backfill acted as a filter.

It retained the fine particles, the natural dusts contained in the sand, limiting turbidity outside of the caisson belt.

The ground gradually emerged, as the volume of sand in the enclosure increased, the water level decreased. The land was competed on 14th December 2019.

→ *Figure 56: Belt closure at the Larvotto side*

SAFETY AT CONSTRUCTION SITE

A dedicated team of professionals ensures safety at the Anse du Portier construction site.

They are composed of experts in maritime works and specialists in land works, who are well able to meet the requirements of the project and the standards of Bouygues TP Monaco and other companies involved.

Safety at sea which is specific to this project is ensured in close cooperation with the Maritime Affairs Directorate and the Maritime Police.

A dedicated speedboat operates to monitor the activities and interventions on the water.

Safety on land is also essential.

All engineers and technicians work closely with the Department of Public Security to ensure that clearly marked signs allow appropriate interactions between site workers and local residents.

↗ →Figures 57 and 58: 3D plan and aerial view showing completed belt and backfill

June 2020

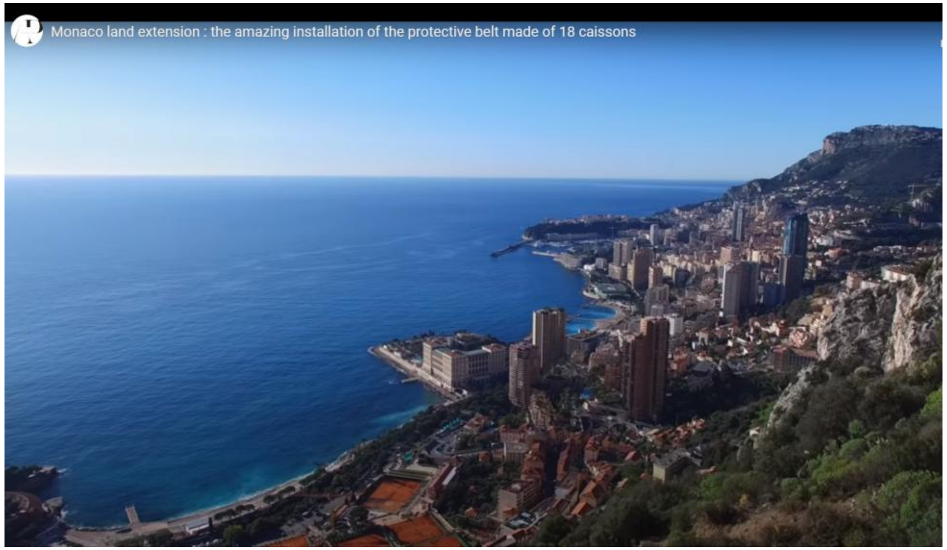
PROJECT MILESTONES	
July 2015	Contract - Execution and Signing
July 2016	Approval of design studies
July 2017	Start of works and arrival of a floating dock ´Marco Polo´ in Marseille
July 2018	First Caisson arrived in Monaco from Marseille
Late summer 2019	Last caisson installed (C00 for the swimming pool)
14 December 2019	Completion of the land platform on which the new district will be built
17 March 2020	First step of delivery to customer

MAJOR MILESTONES IN CONSTRUCTION	
October 2016 – May 2017	Environmental preliminary works
May 2017 – February 2018	Dredging works
December 2017 – June 2018	Setting of bedding backfill
July 2018 – December 2018	Vibrofloation of backfill
Sept 2018 - Sept 2019	Setting of caissons and ballasting
February 2019 – August 2019	Setting of technical backfill
February 2019 – spring 2020	Setting of breakwater rocks
October 2019 – Dec 2019	Sand base backfilling

MAJOR QUANTITIES

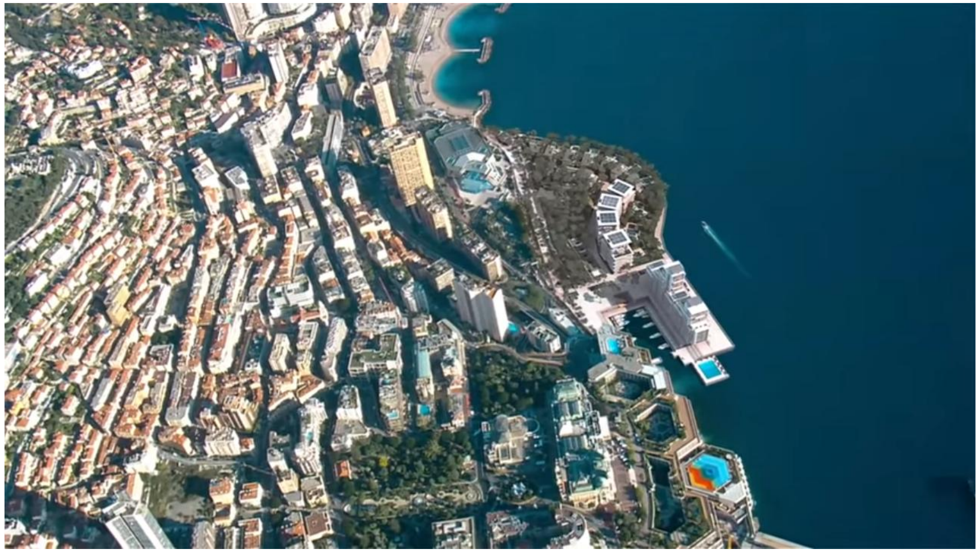
- 80,000tonne of riprap rocks (4/10 mm) set on the existing embankment, including 46,000tonne sunk for an artificial reef
- 65,000m^3 of sediment materials treated
- 50,0000m^3 of existing sediments excavated
- 2,000,000tonne of quarry material (20/180mm) transported from Fos-Sur-Mer and La Seyne-Sur-Mer harbours and used to build foundation backfills, technical backfills and embankments
- 140,000tonne of backfill materials for foundation of the future platform used for the future building
- 370,000tonne of of quarry material 0/20 mm for ballasting caissons, loaded in La-Seyne-Sur-Mer Harbor
- 110,000tonne of riprap rock set for protection of the embankment and 25,000tonne of riprap rock to protect the Larvoto embankment, loaded in Piombino and Imperia harbours (Italy)

VIDEOS



Video: Timelapse of the Monaco Land Project

Click on the image to play the video



Video: Portier Cove Project Overview

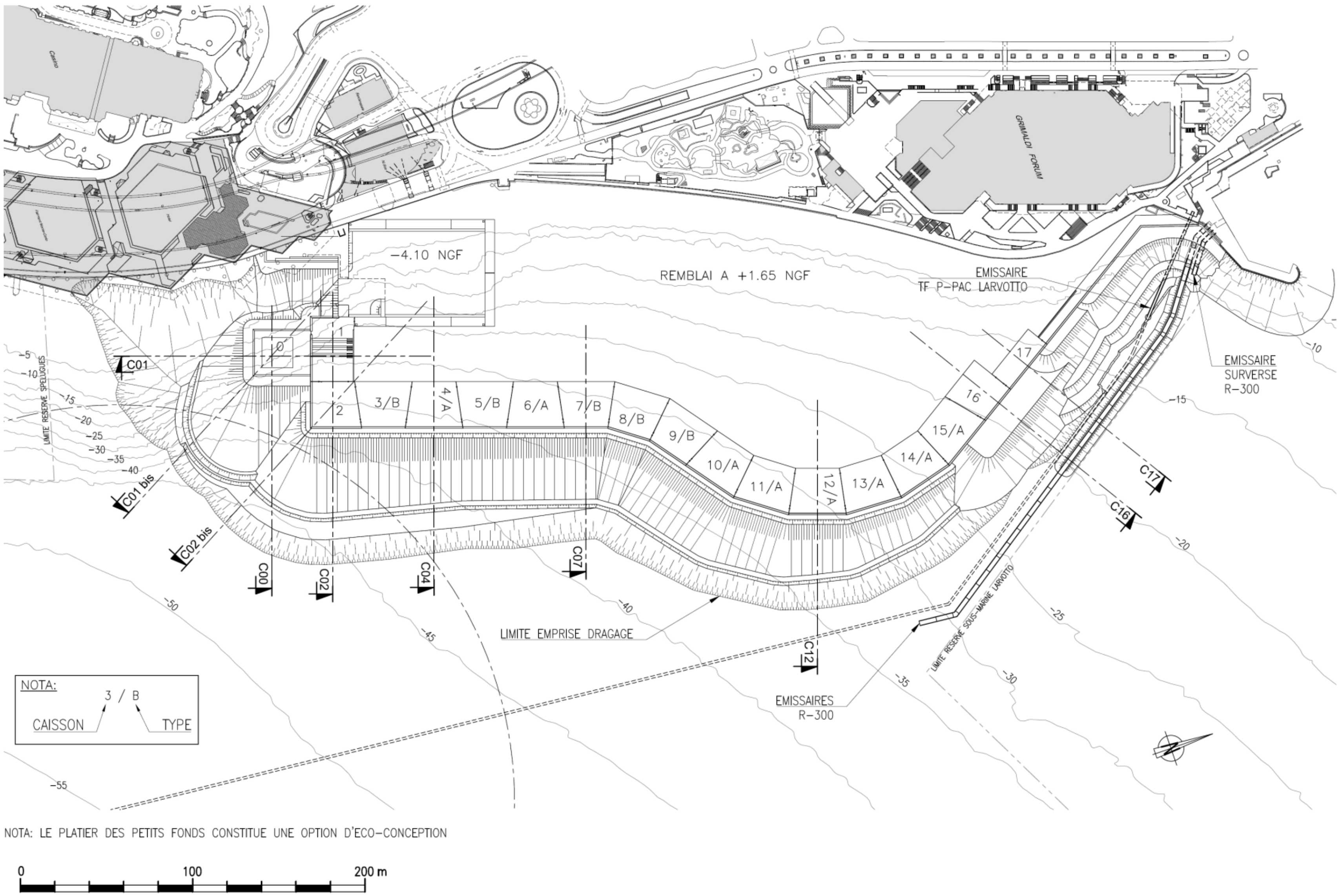
Click on the image to play the video

Construction timelapses see at Anse du Portier website

Videos / Timelapses

June 2020

PLAN VIEW



Plan View of the Monaco Land Project – Click on the image to see it in full

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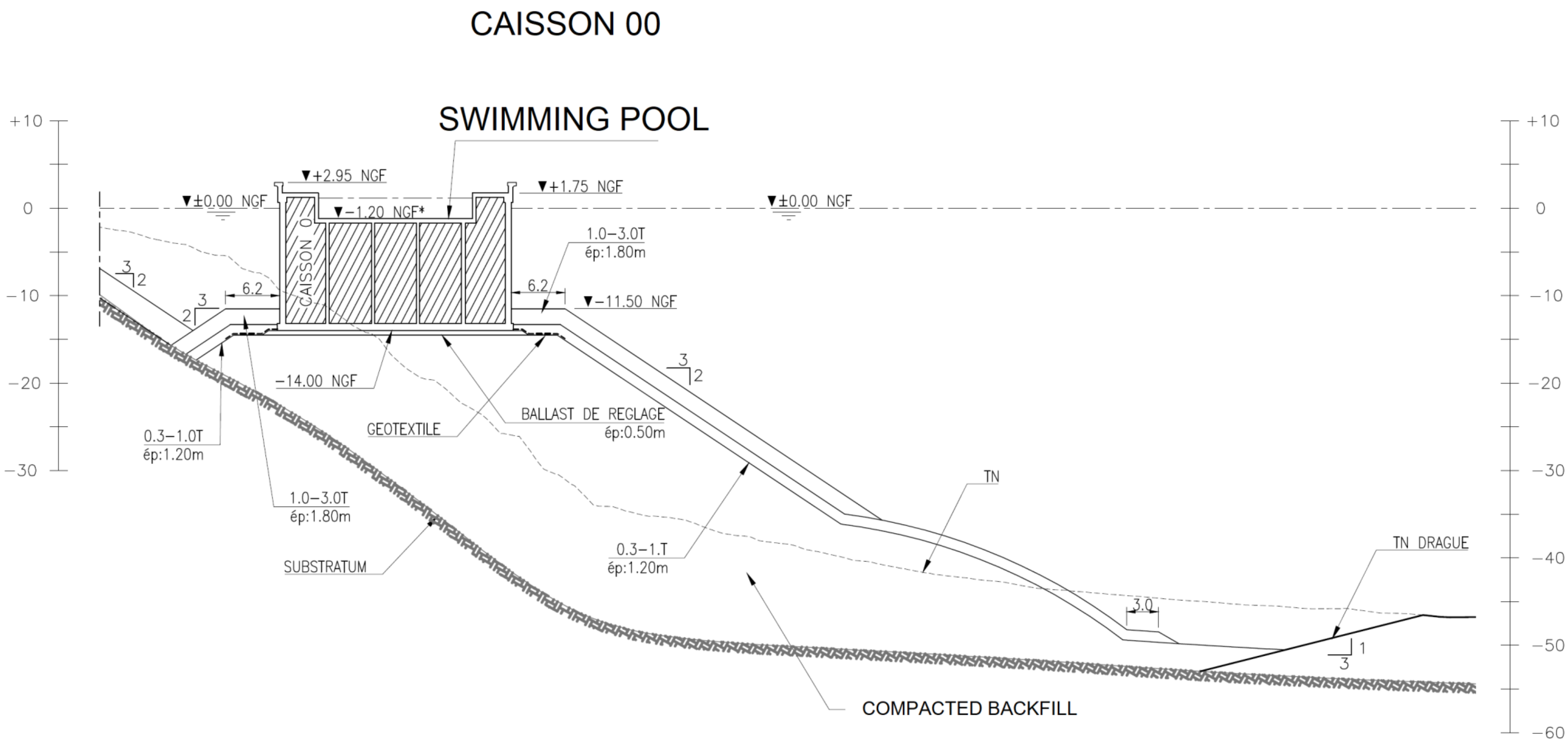

Section of Caisson 00 for the Swimming Pool – Click on the image to see it in full

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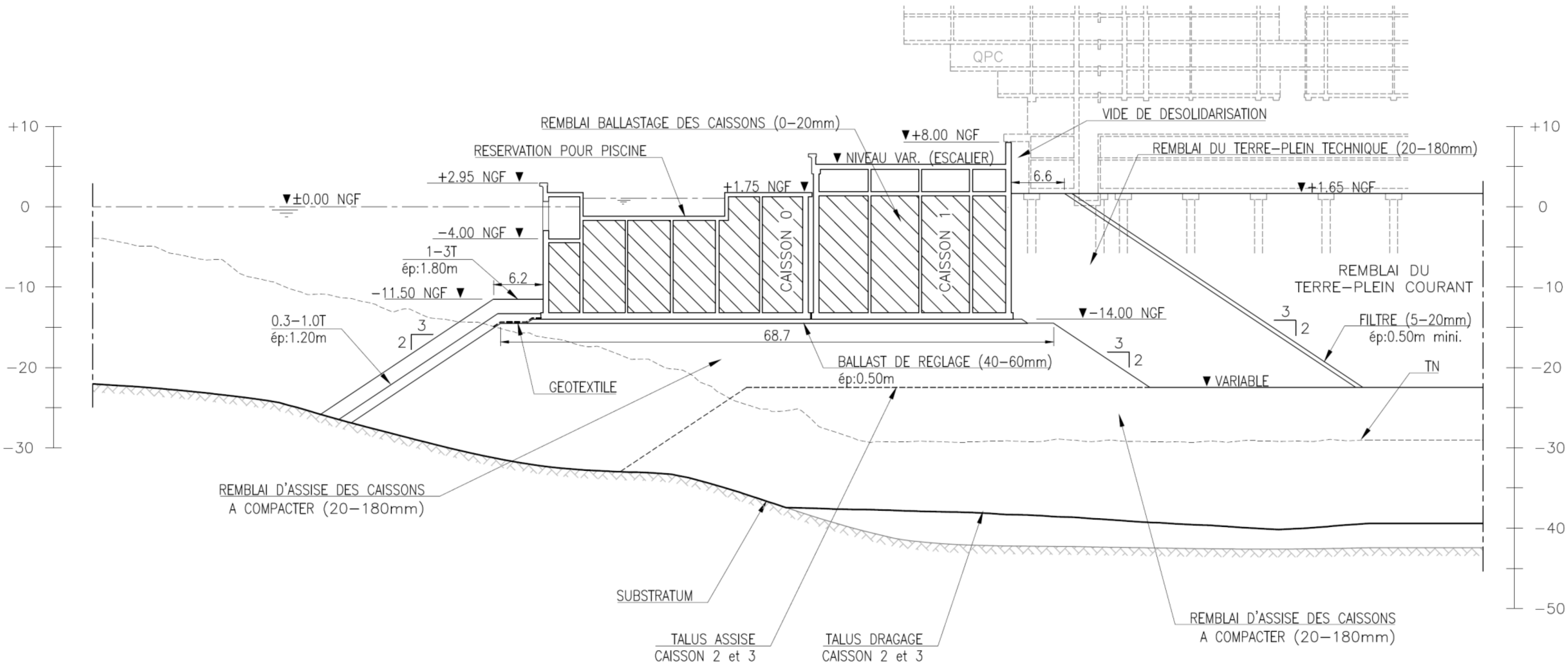
CAISSON 01



Section of Caisson 00 for the Swimming Pool and Caisson 01 – Click on the image to see it in full

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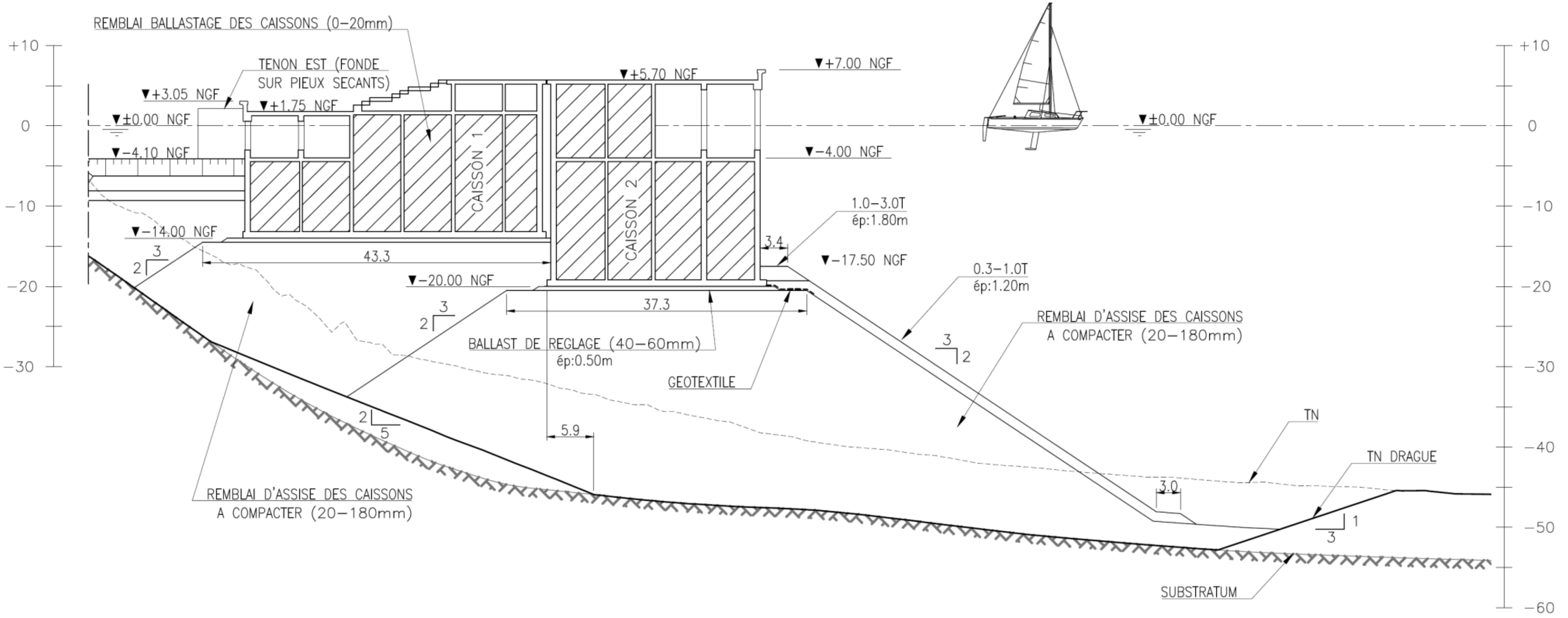
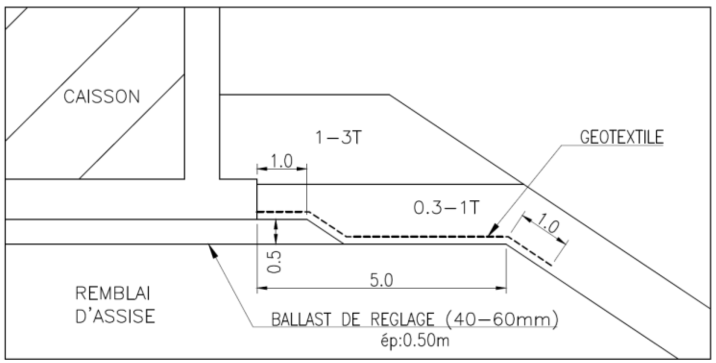
CAISSON 02





Section of Caisson 01 and Caisson 02 – Click on the image to see it in full

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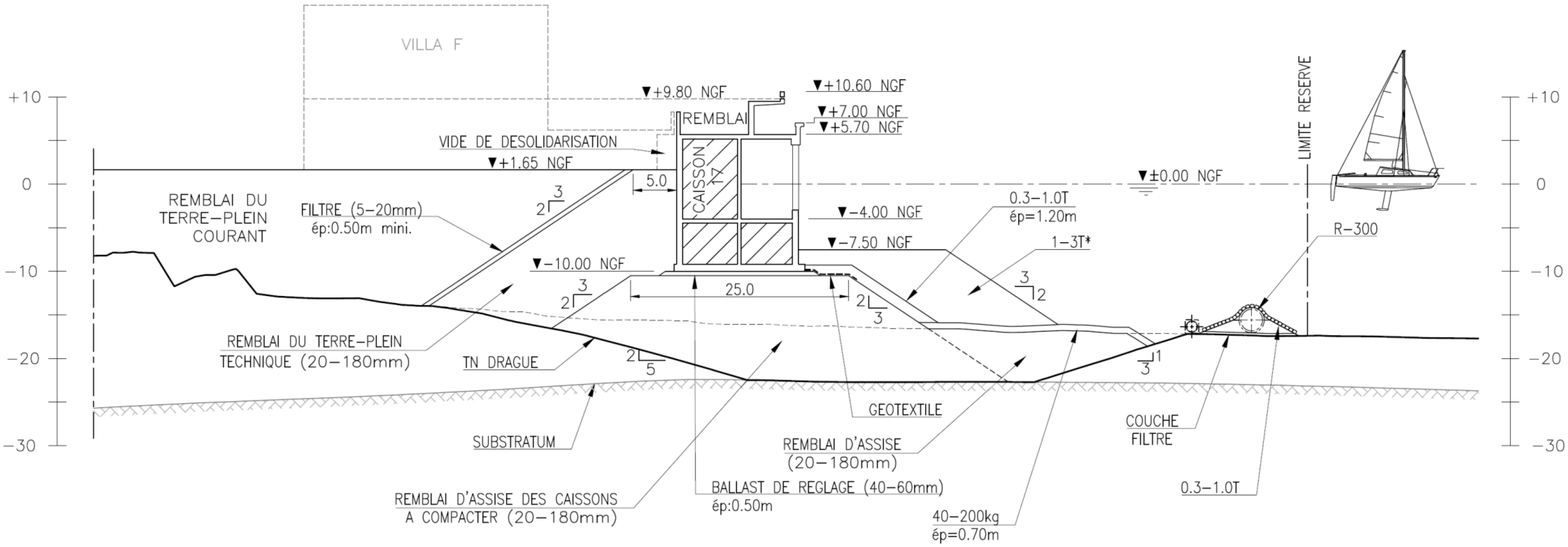
CAISSON 17



Section of Caisson 17 – Click on the image to see it in full

VESSELS AND EQUIPMENT
USED FOR MONACO LAND PROJECT

NB 56 FLOATING DOCK ´MARCO POLO´

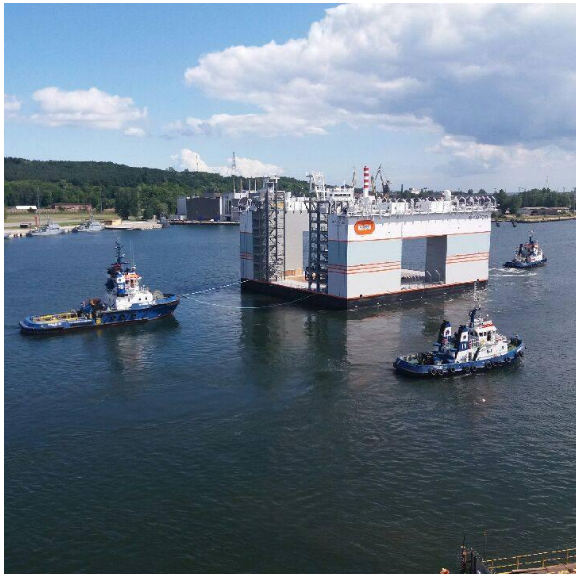
The floating dock MARCO POLO was built by Polish shipyard Crist for the French construction company BOUYGUES TRAVAUX PUBLICS.

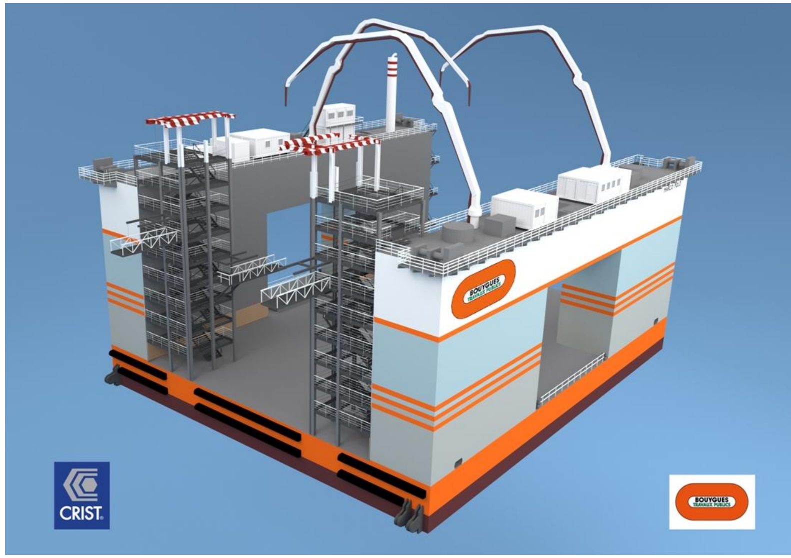
It was used to construct the caissons of the Monaco Land Project.

The vessel is 56m long, 50m wide and 27m high. The gross tonnage equals nearly 8,000tonne.

The task of the shipyard was to develop, construct and test the new unit.

Figure 1: View inside ´Marco Polo´, HPR Havyard Production





↑ *Figure 3: 3D Scheme of ´Marco Polo´*

↖ *Figure 2: ´Marco Polo´ in Poland, August 2017, Crist Shipyard*

The floating dock was equipped, among other things, with an innovative ballast and measurement system ensuring continuous levelling of the unit, safety during work and protection against wind, waves and currents.

After completion, it was transported from Poland to the Port of Marseille in France.

The operation was done by Bolloré Logistics Poland in 2017 with the team of 30 experienced professionals and it involved:

- Towing the floating dock MARCO POLO from shipyard's quay to anchorage area by four tugs;
- Positioning the floating dock on the submersible / heavy lift vessel ´Sun Rise´;
- Customs clearance T2L, Harbour Master permission, Port fees;
- Single Voyage Declaration, Towing Train Certificate from Polish Ships Registry;
- Non-destruction Tests of welded stowage;
- Assistance during the FLO-FLO loading operation on the Bay of Gdansk.

This operation lasted for 11 hours and was completed successfully.

After the loading on the vessel, Marco Polo was transported to Marseille, France.

After a construction period of about 10 months, followed by a 14-day voyage taking it across the North Sea, the English Channel, the Atlantic Ocean, the straits of Gibraltar and finally the Mediterranean Sea, on 21 August 2017 the floating dock arrived at its final destination: The Port of Marseille.

The towing operation consisted of what is called a Dry Tow.

This floating dock is in fact a submersible vessel whose ballast tanks can be filled so that it sinks. The equipment to be loaded is then positioned in the water above the submerged vessel, the ballast tanks of which are then emptied, thus bringing it up to the surface once more.

The equipment is thus lifted out of the water and remains in place on the floating dock.

For 18 months from October 2017 the teams from Bouygues Travaux Publiques produced one caisson per month, working around the clock in three eight-hour shifts.

This gigantic and unique structure is based on one simple principle: using sliding formwork, each of the 18 reinforced concrete caissons could be constructed by progressively raising the concrete walls.

The taller the caisson grows, the further the floating dock sinks into the water under the additional weight, making the construction process easier.

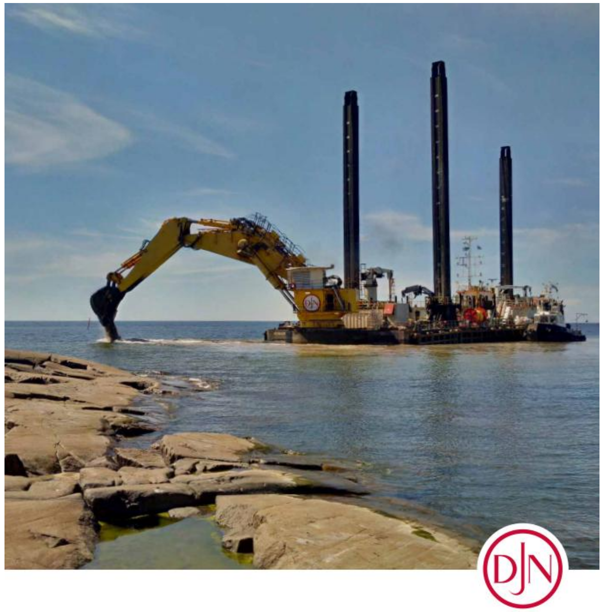
The caissons are trapezoidal and in different sizes, from 14.5m high for three of them to 24.4m high for the others.

The largest weighs some 10,000tonne.

Video: First Caisson Construction. To play the video click on the image

MIMAR SINAN

Backhoe Dredger equipped with a hydraulic crane that can excavate soil and rock wall from 15m^3 to 40m^3 with its mechanical shovel.



Reference:

TIGER

Split Hopper Barge used to load and transport dredged soil.

Reference:

e-maritime

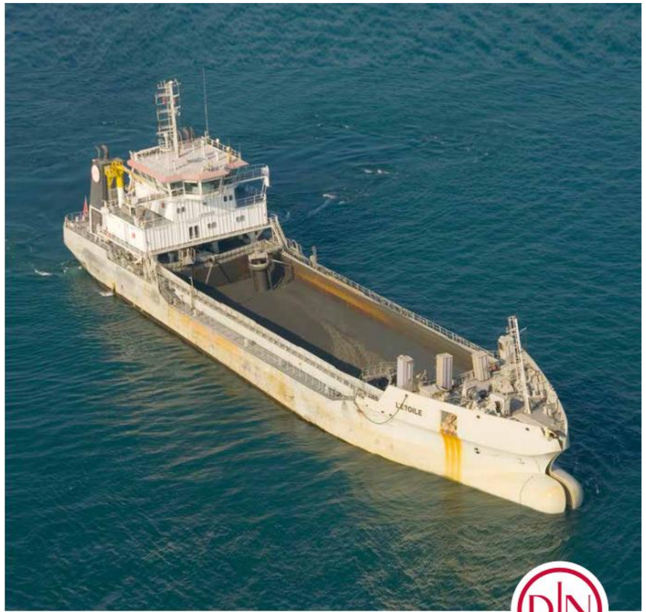
SPHINX

Split Hopper Barge

Reference:

ETOILE

Split Hopper Barge



Reference:

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FRANCIS BEAUFORT

Trailing Suction Hopper Dredger

Reference:

SIMON STEVIN

DP2 Fall Pipe Rock Installation Vessel

Reference:

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DANIEL BERNOULLI

DP2 Trenching and Offshore Support Vessel Subsea Rock Installation Vessel

Reference:

LEIV EIRIKSSON

Trailing Suction Hopper Dredger

Reference:

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FABIO DUO

Hopper Dredger

Reference:

VB FOS

Tug Boat

References:

https://www.boluda.com.es/en/details-vessel/VB%20FOS/

http://www.boludafrance.com/en/2018/09/04/boluda-france-successfully-completes-the-towage-of-the-first-concrete-caisson-built-for-the-monaco-extension-project/

e-maritime

STORNES

Flexible Fallpipe Vessel

Reference:

NORDNES

Flexible Fallpipe Vessel

Reference:

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OMVAC OCHO

Trailing Suction Hopper Dredger

Reference:

TERTNES

Self Discharging Bulk Carrier

Reference:

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BARGE EDMOND

BARGE FILIPPO

←

BARGE JD1

→

BARGE FRANCESCA

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