Living with the winds and tides.

RIVER AND MARITIME WORKS

BOUYGUES TRAVAUX PUBLICS

Shared **innovation**

The strength of experience.

For more than 35 years, Bouygues Travaux Publics has been a major player in the river and maritime works market. Our business lines cover the design, construction and renovation of specific structures such as breakwaters, docks, locks and dams, as well as complete port projects and urban development projects at sea.

Proficient in all construction methods, we have built our reputation on our ability to design and build complex projects involving a wide variety of structures, and to design customised tools and solutions tailored to our clients' needs as well as the constraints of the environments in which we operate.

Bouygues Travaux Publics is backed up by the collective intelligence of its network of industrial and academic partners and provides its expertise across the entire construction value chain.

←

Beirut waterfront [Lebanon, 2000]

Standing up to the test of time.

With projects such as those of Beirut, Méricourt, Tangier, Monaco, Reunion Island and Fécamp, Bouygues Travaux Publics has delivered numerous turnkey river and maritime projects in France and abroad.

Structures of all sizes: from the most common projects to the offshore extension of the Calais port. Innovative structures: from the *N'Kossa* barge to the Monaco offshore extension. Structures for all uses: developing habitable space and optimising coastal areas, improving port accessibility, linking people and places, contributing to the development of renewable marine energies.

We are now ready to rise to the challenges of the future: adapting coastal areas to cope with climate change, designing low-height protective structures and rehabilitating existing structures. As a responsible builder, we are constantly improving the durability of our structures in order to preserve resources and minimise humankind's impact on its environment.

→

Maritime infrastructure of the Principality of Monaco offshore extension [Monaco, 2019]

Living with the winds and tides.

In order to withstand winds, swells, tides, rising sea levels and currents, the design and construction of maritime structures require a comprehensive knowledge of the natural environment and its potential impacts, both during the construction phase (storm management, scouring control, etc.) and during the operational phase (effect of harbour agitation, sedimentological impact, control of overtopping, etc.).

Whether it is to refine the size of structures, optimise their functionalities and their environmental integration or adapt to the day-to-day requirements during the construction phase, our teams are attentive to nature. This is the spirit that drives us.

Thanks to its technical department, Bouygues Travaux Publics has the skills and tools needed to model the marine environment and its interaction with structures, while maintaining a permanent scientific watch. This added value is essential in a sector where the contexts are varied and subject to constant modification due to climate change.

←

Present on every continent, Bouygues Travaux Publics and its 5,000 staff work on projects of a highly technical nature.

Port breakwaters

The purpose of breakwaters is to **protect** port infrastructures from waves. There are two main types of structures:

- **Rubble-mound breakwaters,** built with quarry materials and artificial blocks;
- **Vertical breakwaters,** mainly made of reinforced concrete caissons.

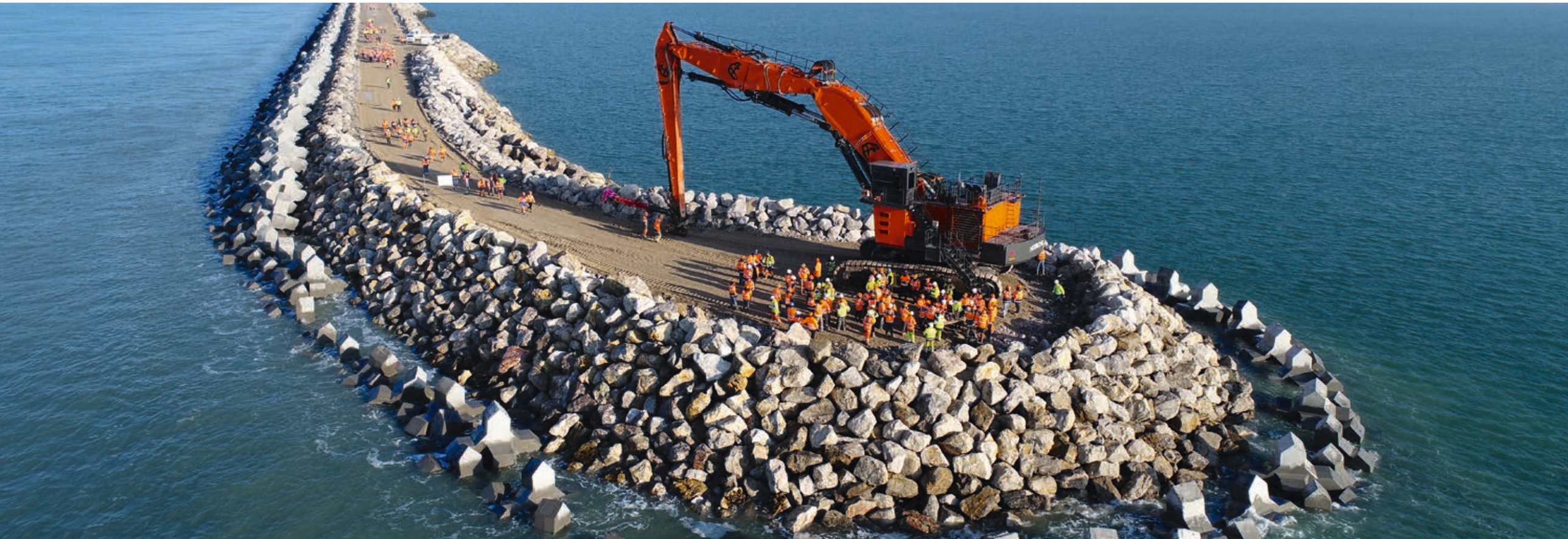
With its extensive experience in this field, Bouygues Travaux Publics is highly proficient in the construction of these two types of structure and offers **innovative solutions** during the construction phase, as in Calais (p. 14-15), where the automation of the construction process for the rubble-mound has made it possible to limit the need for divers to work in difficult conditions.

Bouygues Travaux Publics' added value also lies in its ability to **optimise** the design of structures. Over the course of many projects, the teams in the technical department have acquired a real expertise in the design of breakwaters, the monitoring and interpretation of model tests and calculations of wave agitation.

This experience and expertise allow us to assist our clients in their choice of construction of a rubble-mound or a vertical breakwater, or even a combination of both, in order to reach an optimum solution, technically and economically.

This global vision of **designer-builder** can lead, as it was the case for the Tangier Med 1 and 2 port projects (p. 10), to completely rethinking the master plan of the port infrastructure project by taking into account all the expected functionalities (ease of navigation, protection against wave agitation) while optimising the breakwater structures.

↓ Calais Port 2015 [France]



MONACO 2001

Port Hercules

Execution of a protective platform area and a counter-jetty

LENGTH OF THE BREAKWATER
145 m

BUILDABLE AREA RECLAIMED FROM THE SEA
1.2 ha

CAISSONS
6

The Principality has been widely developed on the sea: it took only 30 years for this territory to double its surface area by extending itself little by little into the Mediterranean. The project to extend the port began in 1999 and reclaimed an additional hectare to build an outer harbour allowing Monaco to double its mooring capacity and accommodate cruise ships and pleasure crafts. Renamed Hercules, this outer harbour required the construction of innovative maritime structures to meet the geological constraints of the area: **great water depths** with considerable variations, complex and heterogeneous natural soils. In this context, Bouygues Travaux Publics built a protective platform structure and a counter-jetty resting on six reinforced concrete **caissons of variable geometry**. Those were manufactured in the former shipyards of La Ciotat and towed to their final location. To accommodate them, two six-storey high fills ensured the stability of the structure on complex, shifting sea beds.

FRANCE 2008

Port du Château

Construction of two fixed breakwaters on piles, a pontoon and the operations buildings of the new marina of Brest

LENGTH OF THE BREAKWATERS

MAIN
= 470 m

SECONDARY
= 170 m

SLABS
69

A former military area returned to civilian use in 2005 as part of a plan to rationalise the property assets of the French Navy, the Port du Château brings yachts and sailboats into the heart of the city of Brest. To develop this **marina**, which has been designed to accommodate nearly 600 pleasure and racing boats, the maritime metropolis undertook colossal works in 2006. Two seawalls of 470 and 170 metres in length replaced the former breakwaters made of grounded navy vessels. They provide protection against the motion within the basin and offer, except when there are storms, a space for visitors to stroll. Adapting techniques from **offshore construction**, a first for a marina, the anchoring of the support piles for the southern breakwater was carried out by means of tie rods passing through the piles and fixed in the rock. 69 slabs weighing 70 tonnes each, prefabricated in the nearby commercial port, ensure the solidity of the southern and western structures. **Concrete wave-guard walls**, 13.45 metres high, complete the structure and protect the 11-hectare stretch of water, while limiting its silting up.

MOROCCO 2001

Tangier Med Port 1 and 2

Design and construction of the Tangier port and its extension

LENGTH OF THE BREAKWATERS

MAIN (MED 1)
= 2,640 m

MAIN (MED 2)
= 3,665 m

SECONDARY (MED 2)
= 718 m

Until the end of the last century, Oued Rmel, 40 kilometres east of Tangier, was a sandy beach set against the desert, exposed to both the Mediterranean and the Atlantic swells. Since then, container ships from all over the world have been coming to this port that has enabled Morocco to establish itself as one of the world's maritime trade hubs. In a consortium with BYMARO, a subsidiary of Bouygues Bâtiment International, Bouygues Travaux Publics was entrusted with the design and construction of the Tangier Med 1 port. The chosen **option** involves a combination of breakwaters made of accropodes™ and absorbent caissons depending on the depths. This optimises the mass layout and offers an additional 14-hectare platform. The caissons were built using sliding formwork on land before being launched, and are composed of **over water chambers** with perforated walls on the sea side to reduce the impact of waves and to limit over topping. This port extension included the construction of two new mixed breakwaters using embankments and caissons, as well as 1,200 metres of quays.

MOROCCO 2009

Port of Tangier – Work section 9

Design and construction of a ro-ro port to accommodate ships

LENGTH OF THE BREAKWATERS

MAIN
= 1,230 m

SECONDARY
= 1,200 m

CAISSONS
23
(MAIN BREAKWATER)

After participating in the construction of the strategic port of Tangier Med 1, Bouygues Travaux Publics was entrusted in a consortium with BYMARO, with the design and construction of the city's new port terminal for **roll-on/roll-off ferries** (ro-ro). The alternative plan made it possible to offer ships a greater ease of navigation and to favour a radial layout around the entrance channel. Two breakwaters of 1,230 and 1,200 metres in length, eight berths for ferries consisting of quays blocks and mooring **dolphins** and a 42-hectare logistics platform were built. The main breakwater is made up of two sections: a first section with an embankment, protected by a shell made of accropodes™, and a second section made up of 23 reinforced concrete caissons, that were prefabricated and then immersed. The use of prefabricated caissons permitted the shortening of construction time and a narrower breakwater to be built. This lowered the environmental impact of the project, thanks to a reduction of the site footprint and volume of materials used.

FRANCE 2010

Erquy Port extension

Dismantling and reconstruction of a mole

LENGTH OF THE QUAY
430 m

ADDITIONAL WATER SURFACE AREA
4 ha

As a fishing port hosting some 60 vessels that unload 10,000 tonnes of fish and shellfish each year, the port of Erquy is vital to the maritime economy of Brittany. In order to carry out the **renovation** and extension operation commissioned by the Côtes d'Armor department, it was necessary to simultaneously dismantle the existing mole, which had been damaged by the elements, and the reconstruction of the replacement mole, without jeopardising the port's protection against swell. This extension provides an additional 4-hectare **stretch of water** and new **quays**. To minimise the impact of the work on road traffic, particularly during summer, a concrete plant was installed on site and materials were transported by sea from nearby quarries. A concrete, whose tints resemble those from the Pink Granite Coast, was used.

FRANCE 2023

Port of Port-La Nouvelle

Execution of the port extension works

LENGTH OF THE NEW NORTHERN BREAKWATER
2,430 m

LENGTHENING OF THE SOUTHERN BREAKWATER
600 m

ACCROPODES™™
17,000

The port of Port-La Nouvelle, located in the Aude department, is the third largest French port in the Mediterranean. As part of its *Plan Littoral 21* port development strategy, the Occitania region has engaged in a project to extend the port of Port-La Nouvelle in order to further the development of maritime traffic and host new industrial projects related, in particular, to renewable marine energies. The works led by Bouygues Travaux Publics include the construction of a new port basin consisting of two **rubble-mound breakwaters**, 600 and 2,430 metres long, as well as the construction of quay site and the northern platform of 4.5 hectares within the basin. Built from riprap, the seawalls are reinforced with a shell of prefabricated **accropodes™** built on-site. These extremely strong concrete blocks are designed and scaled to resist wave action on the breakwaters and break the energy of the swell. The new harbour basin will accommodate the new generation of 225-metre-long and 36-metre-wide ships.

FRANCE **2021**

Calais Port 2015

Design and execution of the port of Calais extension works

With a high growth in cross-Channel traffic being expected by 2030 and increasingly long ferries, the Port of Calais decided to anticipate these developments by launching Europe's largest port infrastructure project, "Calais Port 2015", in 2015. This large-scale project included the creation of a 177-hectare **basin** and a 90-hectare dock, protected by a breakwater more than three kilometres long, the construction of three new **berths** for ferries and the development of 65 hectares of platform area – including 45 hectares reclaimed from the sea. The construction of the breakwater required the installation of nearly 17,000 **Xblocs®**, cast concrete block from 4 to 12 m^3, whose X-shape and interlocking structure are designed to resist swells while dissipating wave energy. Manufactured in an automated factory, built on site and specially designed for the worksite, the Xblocs® are installed using two techniques: an echoscope and the POSIBLOC™ system, which consists of cells incorporating a GPS beacon, temporarily fixed to each Xbloc®.

LENGTH OF THE BREAKWATER
3,260 m

PLATFORM AREA RECLAIMED FROM THE SEA
45 ha

XBLOCS®
NEARLY 17,000

Quays and wharfs

Quays and wharfs are structures that provide the **interface**, via a berthing area and a mooring system, between a port basin and its operations on land. There are three main types of quay walls:

- **Gravity quay walls,** generally constructed from concrete blocks or caissons;
- **Sheet pile quay walls,** consisting of an anchored retaining wall;
- **Pile supported decks,** consisting of a system of piles, with or without an embankment, supporting concrete slabs.

Bouygues Travaux Publics is highly proficient in the design and construction methods of these three types of quay walls. We use our consultancy skills and expertise for our clients and, as more projects are completed, have developed increasingly innovative solutions to improve **delivery times.**

Thanks to the expertise of its teams, Bouygues Travaux Publics is also involved in projects to **reinforce** or **upgrade** existing structures to increased operating requirements, to new operating conditions (increased loads, higher draught) or environmental requirements. As the original plans are often not available, these complex projects require the services of experts with an in-depth knowledge of the evolution of construction techniques over several decades. The objective being to reuse the existing structures as much as possible and to carry out work in such a way as to minimise the impact on port operations and the environment.

↓ Calais Port 2015 [France]

DOMINICAN REPUBLIC
2003

Port of Caucedo terminal

Design and construction of the island's first cargo port

TYPE
SHEET PILE
QUAY WALLS

LENGTH OF
THE QUAY
630 m

SURFACE
AREA OF
THE PLATFORM
70 ha

Completed in 2003 in record time, Puerto Caucedo is the first multimodal cargo port in the Caribbean. Ideally located, it enables the largest container ships from Europe and Asia to reduce their journey time. By designing an ingenious **alternative**, Bouygues Travaux Publics reduced the overall cost of the project while improving navigation conditions for ships by widening the entrance channel: the 630-metre quay, which was initially to be constructed by means of a sand reclamation in the sea, was built on land. To do so, Bouygues Travaux Publics built an **anchored wall**, whose dimensions were optimised by taking into account the proximity of the suitable building land in place, made up of fossilised coral with a good mechanical resistance. In addition to the quay, the operation included the design and construction of a protective breakwater, a platform area for container storage, operations buildings, traffic lanes and necessary miscellaneous external works.

FRANCE 2008

Saint-Guénolé Quay

Execution of the restructuring work of the port of Saint-Guénolé

TYPE
GRAVITY
DOCK

LENGTH OF
THE QUAY
158 m

PLATFORM
AREA CREATED
2.65 ha

The modernisation of the port of Saint-Guénolé is part of the wider reorganisation of the ports in southern Finistère and provides significant support to the development of the economic activity of one of the leading sardine ports in France. Fourteen months of work were required to build the 158-metre-long **gravity dock**, the slipway, the 26,500 m^2 of platform area and the dredging work to level the entrance channel. The 76,000 m^3 of material from the **excavation** was entirely reused for the construction of the platform area, which will house a 3,000 m^2 business park.

FRANCE 2015

Development of the Masselin mole and the liquid bulk basin - port of Sète

Rehabilitation of the Masselin mole and construction of two additional berths

TYPE
DOCK REINFORCEMENT

LENGTH OF THE QUAY
470 m

PLATFORM AREA CREATED
750 m²

Under the impetus of the Languedoc-Roussillon region, which has now become Occitania, the port of Sète-Frontignan has entered a new phase in its development, with a particular emphasis on passenger traffic, especially to and from Northwest Africa. To give substance to this ambition, Bouygues Travaux Publics Régions France was chosen to rehabilitate the Masselin mole, the cornerstone of the new passenger terminal. Spread over 10 months, the work consisted of building two additional **berths** by **reinforcing** the two existing quays to accommodate ships with a deeper draught and a length of up to 220 metres. Furthermore, two **roll-on/roll-off** berths, also known as ro-ro berths, are designed to accommodate ships with a mobile access ramp for loading and unloading goods by towing, and a 750-m² quayside platform area completes the facility.

FRANCE 2017

Montoir-de-Bretagne general cargo and container terminal

Execution of the terminal extension

TYPE
PILE DOCK

EXTENSION OF THE QUAY
350 m

As the natural maritime gateway of the Greater West, the Greater Maritime Port of Nantes Saint-Nazaire decided in 2015 to make major investments to support the region's renewable energy industries and also to improve its capacity to accommodate increasingly large container ships. The consortium, led by Bouygues Travaux Publics Régions France, was awarded the contract to extend the fourth berth at the Montoir-de-Bretagne terminal from 250 to 600 metres. The 350 metres of new quay are supported by 580 steel **piles** driven into the bed of the Loire. 1,157 **prefabricated reinforced concrete elements** were positioned on this mesh structure to form the quay's cover slab. 200 metres of the new quay were reinforced to allow the handling of heavy goods, such as offshore wind turbine nacelles, weighing up to 500 tonnes. Another unique feature is that the quay is equipped with **sensors** to analyse its behaviour over time and to monitor its resistance to various constraints (tides, passage of heavy loads, etc.).

FRANCE 2018

Extension of the Flanders terminal of the Grand Port Maritime of Dunkirk

Execution of the extension works of the Flanders terminal

TYPE
SHEET PILE QUAY WALLS

EXTENSION OF THE QUAY
500 m

BERTHING CAPACITY
2 NEW-GENERATION CONTAINER SHIPS

Completed in 24 months, the work to extend the Flanders terminal now enables the Grand Port Maritime of Dunkirk to simultaneously berth two new-generation container ships, each capable of carrying more than 22,000 TEUs (twenty-foot equivalent units). Extended by 500 metres, the terminal quay has a total length of 1,800 metres and can berth ships with a draught of 16.5 metres in all tidal conditions. The terminal quay is located in sandy soil with clay and silt layers. This specificity obliged the consortium led by Bouygues Travaux Publics Régions France to work using the **combi-wall** technique. Its structure is made up of 205 40.5-metre-long steel **pipe piles** and 410 **sheet piles** driven into the sand. A technique that has already been tried and tested on many projects, the combi-wall on the Flanders terminal quay stands out because of the 40-metre depth to which it was driven and rammed into a grouted wall.

FRANCE 2020

Toulon arsenal – CA0 wharf

Design, construction and maintenance of a wharf dedicated to the movement of pyrotechnic material

TYPE
QUAY WALLS ON PILES

LENGTH OF THE QUAY
180 m

ACCESS STRUCTURE
TRUSS BRIDGE

Toulon military port is the largest industrial site in the Var region, home to most of the French fleet and the largest navy base in France. Bouygues Travaux Publics Régions France completed the construction of a 180-metre long and 17-metre wide **wharf**. This structure, designed to withstand the most extreme conditions, is dedicated to the handling tactical weapons of the French Navy. In addition to this wharf on **piles**, the company built the access structure, a 200-metre-long Warren-type truss bridge, and the services for the new structure. Designed, built and maintained in a military environment, the structure meets the security requirements of the Toulon naval base.
In order to minimise the impact of the worksite on the operation of the naval base, the piles for the jetty were driven from a ripable pile-driving platform and the reinforced concrete slabs were prefabricated at the naval base and then transported by sea.

Offshore extensions and flood defences

All over the world, coastal development projects are on the increase. These are either offshore extension projects, aimed at reclaiming space for industrial activities, residential areas, or coastal development projects intended to provide promenades and, in the context of climate change, to protect the coasts. Coasts are then protected from erosion or submersion arising from the combined effect of rising water levels and storms, which are becoming more frequent and intense.

In both cases, this type of project requires a high degree of proficiency in the construction techniques of:

- **Anti-submersion or anti-overtopping structures:** riprap, sea walls, etc;
- **Anti-erosion structures:** beach sea walls, groynes, T-shaped groynes, detached breakwaters, etc.

Construction techniques for these structures are similar to those used for port sea walls, but their design often requires the integration of specific **architectural constraints**. The challenge is to limit the number of over toppings as much as possible, while reducing the visual impact of these structures on their environment. Thanks to an active R&D policy in this area, Bouygues Travaux Publics is able to offer its clients innovative anti-overtopping measures. For the Beirut seafront project (p. 26), "**wave traps**", coupled with absorption chambers, were designed and built to trap the mass of water that overtops an initial threshold, thereby reducing the number of over toppings likely to reach the area to be protected.
In Monaco (p. 30), the offshore extension project benefited from the installation of porous chambers with double-perforated walls to limit wave reflection as much as possible.

↓ Beirut seafront [Lebanon]

LEBANON **2000**

Beirut seafront

Construction of the city's seafront promenade and marina

As the culmination of an ambitious project to rebuild the city centre of the Lebanese capital, the Beirut seafront and marina project comprises two breakwaters with very different profiles, allowing 60 hectares to be reclaimed from the sea. The first was designed to accommodate a prestigious three-level promenade, protected from overtopping that could be caused from swells of up to nine metres. With a length of 1.3 kilometres, this belt is made up of 80 **wave-absorbing caissons**, equipped with a double absorption chamber with decreasing perforation rates and a "**wave trap**" that absorbs almost all the overtopping and empties it into chambers. Precast on land, the reinforced concrete caissons were then immersed, ballasted, towed out, and positioned side by side, then filled with sand and finally closed with a one-metre-thick concrete plug. A second 450-metre-long breakwater protects the marina, which can accommodate 400 pleasure boats, including some large yachts. Two staggered crest walls surmount this breakwater to block overtopping without obscuring the view from the neighbouring hotels.

SURFACE AREA
60 ha

CAISSONS
80

ACCROPODES™
10,000

FRANCE 2019

Enclosing dyke for a new polder in the port of Brest

Construction of a sea wall

ADDITIONAL AREA
14 ha

CIRCULAR COFFERDAMS
26

RIPRAP
800,000 t

To support the development of marine renewable energies, the Port of Brest has undertaken the construction of a new terminal dedicated to the handling of goods related to their operation. Several worksites have been launched, including that of the **enclosing dyke**, the first stage in the creation of a new 14-hectare polder that will house part of the facilities. This contract, awarded to Bouygues Travaux Publics Régions France, includes the construction of an 890-metre-long arched dyke to close off an "enclosure" where the marine sediments dredged from the port will be stored, in other words 1.25 million m^3 of sediment. The dyke is composed of 26 **circular cofferdams** interconnected by curved walls, made of sheet piling 21 to 33 metres long. This solution was chosen instead of a rubble mound as it offered a greater storage capacity for sediments. The dyke also incorporates eco-reefs that retain water at low tide to preserve ecosystems.

HONG KONG 2020

Tuen Mun - Chek Lap Kok Link – Northern embankment

Construction of an offshore extension including the access tunnel to the sub-sea tunnel

SURFACE AREA
16.5 ha

The Tuen Mun-Chek Lap Kok Link five-kilometre twin-tube tunnel connects the New Territories to the artificial island housing the Hong Kong-Zhuhai-Macao Bridge border checkpoint facilities and provides faster access to the international airport. In order to accommodate the launch shaft for the tunnel boring machines and the shaft giving access to the underwater tunnel, an offshore extension of 16.5 hectares was built. This extension, which consists of a concrete block quay wall to the east and a rockfill breakwater to the west, was the starting point for an exceptional project. With a dredging permit limited to the peripheral base of the extension, the consolidation of the central part, crossed by two tunnel boring machines, including the world's largest earth pressure tunnel boring machine (17.63 metres in diameter), was carried out by installing **vertical drains** in the marine deposits and accelerated by the use of a **preloading fill**. Once the offshore extension was completed, the areas created were used for the logistics of the works and then transformed to accommodate the tunnel ventilation building and land areas for port business activities.

MONACO **2020**

Monaco offshore extension

Construction of the maritime infrastructure of the new district of the Principality

Both a city and a state, Monaco is a territory that must reconcile its economic and demographic dynamism with considerable space constraints, landlocked between mountains and sea. In the spring of 2013, H.S.H. Prince Albert II. decided to launch a new urbanisation project at sea with the creation of a six-hectare eco-district. The maritime infrastructure, built by Bouygues Travaux Publics, consists of an in-filled area surrounded by a **protective belt** made up of 18 reinforced concrete caissons placed on an underwater embankment made of quarried material and compacted into seascapes. These **caissons**, which are 26 metres high and weigh 10,000 tonnes, were built in Marseille in a structure that is unique in France: a 4,600-tonne floating and submersible dock, the *Marco Polo*. They each have an **absorption chamber** with a series of openings on the sea side, Jarlan slots, which break wave power and absorb swell energy. Located between two protected marine areas, the Larvotto and the Spélugues reserves, the work on this marine infrastructure project was subject to continuous monitoring and follow-up. Bouygues Travaux Publics developed new methods and technologies to minimise the impact on the marine environment.

AREA RECLAIMED FROM THE SEA
6 ha

CAISSONS
18

Maritime and river works related to transport infrastructures

Hong Kong-Zhuhai-Macao Bridge [China]

Bridges, viaducts, immersed tube tunnels: many types of transport infrastructure integrate structures that provide a **crossing** of the aquatic environment. These maritime or river structures, technically highly diverse, encounter similar problems related to the nature of the environment in which they are constructed:

- Consideration of **erosion and the effects of currents**
- Installation of **protection equipment to work in dry conditions**
- Construction of **supports in the water**
- Design of **protection systems against ship impacts**

Proficient in the entire range of construction techniques for bridges, viaducts, and footbridges, Bouygues Travaux Publics has built its reputation on its ability to construct emblematic structures and to design equipment and **tools tailored** to the natural constraints of the site. Not quite a tunnel, not quite a maritime structure, the immersed tube tunnel is an economically and technically appropriate solution for medium-length or extra-wide crossings.

Our added value also lies in our commitment to R&D. Thanks to its varied and complementary expertise, our technical department is able to study the feasibility of exceptional projects, such as **floating bridges**, mobilising advanced skills in both hydrodynamics and structural calculations.

UNITED KINGDOM **2011**

New Tyne Crossing

Design-build of a new road tunnel, as part of a Public-Private Partnership (PPP)

CAISSON WEIGHT
10,000 t

USE
ROAD

LENGTH OF IMMERSED TUNNEL
360 m

The New Tyne Crossing in Newcastle, opened to the public in early 2011, doubled the length of an existing structure inaugurated in 1967, thus enabling decongestion of a key route for north-south traffic between Scotland and England. The project, spanning 2.5 kilometres, highlights the breadth of Bouygues Travaux Publics' expertise: an immersed tube tunnel made up of **four pre-stressed caissons**, earthworks, road works and traditional tunnels, including two tunnels bored using SCL (Sprayed Concrete Lining). Without interruption to the Tyne river traffic, the existing cast-iron segment tunnel was also upgraded to **current standards**, particularly in terms of lighting, signage, drainage and ventilation. Both the old and new tunnels now benefit from a water mist system for **active fire protection**, a first in the UK at the time.

FRANCE **2015**

Beatus-Rhenanus Bridge

Construction of a bowstring-arch bridge over the Rhine between Strasbourg and Kehl

TYPE
DOUBLE BOWSTRING-ARCH BRIDGE

USE
ECO-FRIENDLY TRANSPORT

MAXIMUM SPAN
130 m

The Beatus-Rhenanus bridge, the first French cross-border structure dedicated to eco-friendly modes of transport, crosses the natural border formed by the Rhine and extends the Strasbourg mobility network to the city of Kehl, in Germany. At 290 metres long and 16 metres wide, this double bowstring-arch bridge with double arches accommodates two tramway tracks as well as pedestrian and cycle lanes. It crosses a 240-metre **river gap** with a clearance of 7.5 metres and only rests on a single pier in the middle of the river, built in a cofferdam, and completed by two abutments on each bank. The complex framework of the bridge, made entirely of steel, was transported by barge in several sections from the manufacturing plant and then stored on the river bank, thus reducing the impact of the construction site on the environment. The installation of the two decks required a great deal of technical expertise: levelling of the deck on the bank; loading from the river bank by launching them onto the barges; placing them on the piers and abutments by moving the **barges**; and finally, adjusting them to their final position.

IVORY COAST 2014

Henri-Konan-Bédié Bridge

Design and construction of a motorway link across the Ebrié Lagoon, linking the north to the south of the city of Abidjan

TYPE
BOX GIRDER BRIDGE

USE
ROAD

MAXIMUM SPAN
50 m

The Henri-Konan-Bédié Bridge is the flagship structure of a 6.5-kilometre stretch of motorway designed for development of the country's economic powerhouse. Supporting a 2 x 3-lane road and stretching over 1.5 kilometres, Abidjan's third bridge connects the Riviera district to the north and Marcory to the south, by spanning the lagoon. One of the very first **concessions** in West Africa, the project comprises two sections of motorway, an interchange and a 21-lane toll plaza. The 1,500-metre-long double deck consists of 2 x 30 fifty-metre-long isostatic prefabricated caissons, laid on a single crosshead, seated on two very deep piles acting as a pier. The deck was slid onto a barge for transfer. It was then positioned using jacks in order to facilitate its installation at low tide, first on a temporary support and then on a permanent support. The construction involved locally recruited teams. **Mock-ups** were made on the ground in order to finalise the formwork for the crossheads and caissons, thus enabling the construction workers to be trained.

CHINA 2018

Hong Kong-Zhuhai-Macao Bridge

Construction of a section of the maritime bridge linking the cities of Zhuhai and Macao

TYPE
BOX GIRDER BRIDGE

USE
ROAD

MAXIMUM SPAN
180 m

The Hong Kong-Zhuhai-Macao Bridge is a 42-kilometre-long set of structures that is part of a 55-kilometre motorway project spanning the Pearl River estuary in the South China Sea. Bouygues Travaux Publics, VSL and Dragages Hong Kong, subsidiaries of Bouygues Construction, were involved in a 9.4-kilometre **viaduct** section of the project linking the island of the international airport to the edge of the territorial waters of Hong Kong by a 2 x 3-lane road over deep sea waters. The viaduct is composed of a 9.4-kilometre-long double deck formed of 5,714 prefabricated segments. This exceptional project was completed using two launching gantries (one on the land part of the structure, the other on the high seas), a 950-tonne **floating crane** and a pair of custom-built lifting frames. Designed to withstand major seismic events, this engineering structure is, to date, the largest maritime bridge in the world and an exceptional project for Bouygues Travaux Publics in Asia.

REUNION ISLAND **2021**

Viaduct of the New Coastal Road

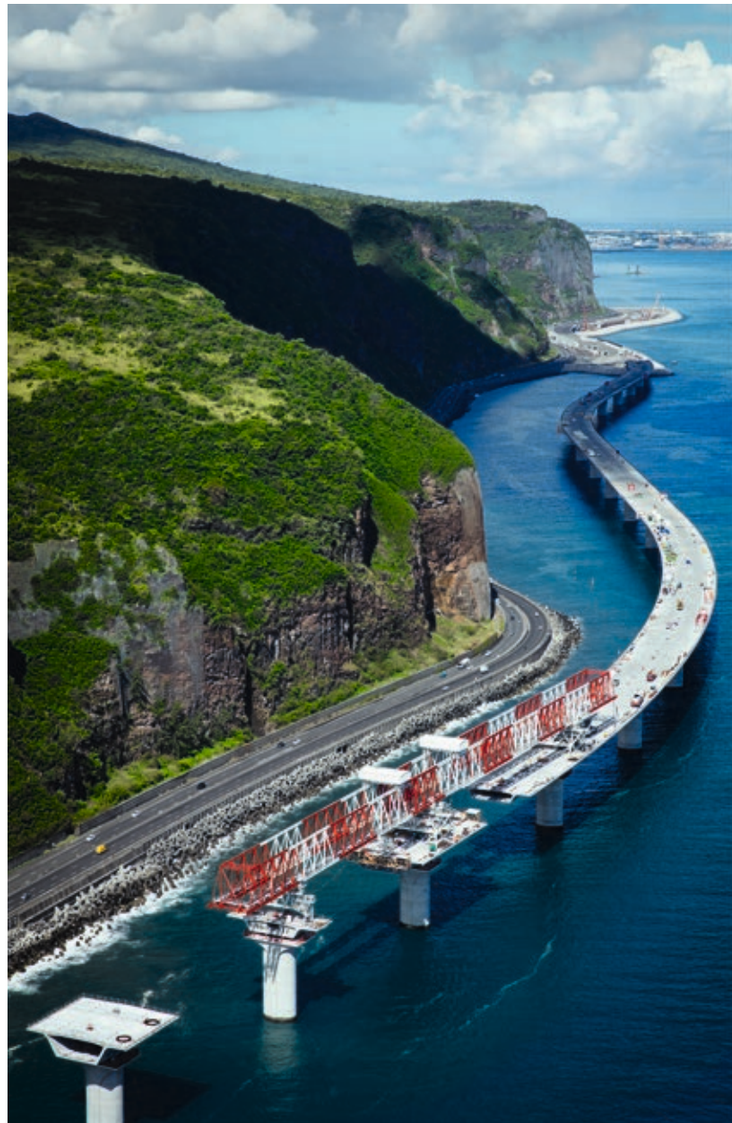
Construction of a sea viaduct, parallel to the coast, linking Saint-Denis to La Grande Chaloupe

Designed to keep vehicles away from the risk of cliff rock falls and to withstand cyclonic swells, this sea viaduct runs along the coast for 5.4 kilometres between the north and west of Reunion Island. Parallel to the coast, this bridge is made up of seven successive decks of 769 metres each. An exceptional structure in terms of its characteristics and its maritime location, it is also exceptional in terms of the diversity of the tools and methods used to build it. 100% of the components of the bridge were **prefabricated** on land in two prefabrication plants and then installed by sea or by a launching gantry. *Zourite*, a tailor-made mega barge, was specially equipped for coastal navigation in difficult seas. Fitted with two overhead cranes and a concrete plant, it mobilised a team of experienced sailors to transport and place on the seabed the components of the 48 piles of what is now **the longest viaduct in French sea waters**. The six piers installed on either side of the Pointe du Gouffre are equipped with eco-designed modules that act as nurseries for the development of underwater flora and fauna.

TYPE
BOX GIRDER BRIDGE

USE
ROAD

MAXIMUM SPAN
120 m



Locks, canals and dams

Whether it is a question of regulating the flow of a watercourse, harnessing hydraulic power or facilitating river transport, the challenge remains the same: not so much to obstruct water but rather to direct it and channel its potential. Bouygues Travaux Publics' expertise in this field is expressed both in the construction and the renovation of three types of structure:

- **Dams,** structures with needle or sluice gate mechanisms intended to regulate the levels of a watercourse;

- **Canals,** structures creating an artificial waterway, either navigable or not;

- **Locks,** manually or automatically operated structures to enable uneven terrain to be crossed.

The construction of these structures requires a high degree of proficiency regarding **construction tolerances**, with the development of very fine adjustments between the various areas of expertise involved: construction, sluice gate and valve mechanisms and mechanical engineering. One of Bouygues Travaux Publics' main added values is its ability to ensure smooth communication between teams of experts used to working together.

Just like maritime works, these river works are also subject to specific constraints in which our teams have a high degree of expertise. Limiting the impact of the construction and operation of structures on water flows is taken into account from the design phase, so as not to harm the biodiversity of rivers and thus respect **natural ecosystems**. The phasing of the works is organised to limit the impact on river traffic and water flows, as well as to favour the **continuity of service** of the structures.

↓ The Mont-Saint-Michel Dam [France]

FRANCE 2008

The Mont-Saint-Michel Dam

Construction of a new dam on the Couesnon river

DAM MOUTH
138 m

SECTOR SLUICE GATES
8

Classified as a UNESCO World Heritage Site, Mont-Saint-Michel would not be the monument we know without its bay. It is the evolution of the bay that almost changed the character of this unique place forever. Because of the tides and human intervention, such as the construction of the causeway or the car park, silting gained ground and threatened the maritime aspect of the Mont and its bay, as well as creating definite risks for the ecosystems that populate it. Major work was undertaken in the 2000s to restore the quasi-natural order with the construction of a new dam over the Couesnon river and hydraulic works downstream, needed for it to work properly. The 138-metre-long mouth of the dam is equipped with nine reinforced concrete piers supporting eight steel **sluice gates**, allowing the rising tide to enter the bed of the Couesnon, and then releasing this volume of water progressively, at ebb tide, in order to drive out the sediments accumulated in the bay and therefore avoid the proliferation of the grasslands.

FRANCE 2013

Chatou Barrage

Reconstruction of a barrage on the Seine

BARRAGE MOUTH
107.5 m

SLUICE GATES
3

FISHWAY
1

The Chatou barrage is located on one of France's most important river routes for the transport of goods, between the ports of Le Havre, Rouen and Paris. It replaces its predecessor, which had been located 50 metres downstream since 1933. Its construction is one of the largest operations ever undertaken by Voies navigables de France (the French Waterways Authority) and was entrusted to a consortium of companies led by Bouygues Travaux Publics. The 107.5-metre-wide structure comprises three 30.5-metre-wide sluices, each fitted with **bottom-hinge gates** operated by hydraulic cylinders. It is equipped with a fishway allowing fish to swim up the Seine without being blocked by the new barrage. Its construction took place in three distinct phases, each of them protected by a cofferdam made of sheet piles driven into chalk. The **phasing of the work** was crucial to ensure hydraulic transparency during high-water periods, between the end of November and the beginning of April. The rest of the time, only one sluice was immobilised by the works.

FRANCE 2015

Saint-Bond Barrage

Modernisation of the Saint-Bond Barrage on the Yonne river

SLUICE GATES
5

FISHWAY
1

It took two years to modernise the Saint-Bond Barrage on the Yonne river to replace the old manually operated barrage, which dated back to 1860 and had become too old, and to ensure sufficient flow of the river. The barrage was rebuilt in stages, using cofferdams, in place of the old structure and is equipped with five **sluice gates** allowing automated management of the stretch of water. Like all the new structures of Voies navigables de France, it is equipped with a **fishway** to allow fish free passage. As part of this renovation, Bouygues Travaux Publics Régions France also constructed a new control room for the barrage and lock, as well as undertaking reconstruction work on the downstream riprap and estacade.

FRANCE 2018

Don lock

Renovation and upgrading of the Don lock on the Seine

LOCK
1

DAILY TRAFFIC FLOW
30 TO 50 BOATS

The Don lock, located on the Deûle river southwest of Lille, allows traffic to flow between the port of Dunkirk and the capital of Flanders. It enables the daily transit of 30 to 50 boats and the passage of 5.3 million tonnes of goods each year. Built in 1956, it benefited in 2017 and 2018 from a major renovation project to meet the increase in river traffic and ensure the safety of navigation on this strategic section of the Franco-Belgian river links. Carried out by Bouygues Travaux Publics Régions France, the works included the replacement of the estacades, the reshaping of the downstream bank with the creation of a pumping station, the modernisation of the control building and the refurbishment of the platform areas. The restoration of the civil engineering structures of the lock, the replacement of the upstream and downstream gates, their operating mechanism and the entire control system as well as the upgrading to modern electrical standards were carried out during a five-week interruption of navigation which allowed the **lock chamber to be dried out**. This operation mobilised up to 110 site workers per day.

FRANCE 2021

Recalibration of the Franco-Belgian river Lys

Recalibration works of the cross-border river Lys between Deûlémont and the Comines lock

SIZE OF THE RECALIBRATION WORKS
5.6 km

VESSELS
BETWEEN 3,200 t AND 6,000 t

A canalised river that becomes the border between France and Belgium donwstream from Armentières, the cross-border river Lys is the central link in the Seine-Scheldt large-gauge European link intended to develop trade between France and the countries of Northern Europe. Initiated in 2018 by Voies navigables de France, the deepening and widening between Deûlémont, in France, and Menin, in Belgium, will make the Lys accessible to vessels with a tonnage from 3,200 to 6,000 tonnes. Along the 5.6 kilometres between Deûlémont and the Comines lock, Bouygues Travaux Publics Régions France carried out, entirely by waterway, the **protection and restoration** work on the curved banks, including reprofiling them, protecting them with either riprap or sheet piling depending on the constraints of the surrounding terrain, and re-establishing the rainwater outlets.

FRANCE 2023

Méricourt Locks

Renovation and lengthening of the locks on the Seine

LOCKS
2

TRAFFIC
30% OF NATIONAL RIVER TRAFFIC

The two locks at Méricourt, built in the 1960s and located in Île-de-France, handle 30% of national river traffic. As part of a vast design-and-build project launched by Voies navigables de France, the renovation and lengthening of the Méricourt locks will restore their original width in order to guarantee their **future stability** and **reliability** in normal and extreme situations. The project includes, in particular, the renovation of the existing locks and the lengthening of the first lock from 160 metres to 185 metres downstream, in order to accommodate convoys of 180 metres in length. In order to modernise the structure, the creation of a new control room for the locks and the barrage, the upgrading of the equipment and the complete renovation of the locks' automatic systems are also necessary. One of the major technical challenges of this almost complete reconstruction is to carry out the work on existing structures while maintaining navigation on the Seine. **Continuity of service** is ensured by one 185-metre lock remaining operational at all times.

Marine structures for energy production and storage

Maritime structures intended for the production of energy include several families of structures:

- **Floating Production Storage and Offloading (FPSO):** floating unit for the production, storage and offloading of hydrocarbons;
- **Marine wind turbines:** wind turbines either installed near the coast (nearshore) or floating offshore to benefit from better wind consistency.

Bouygues Travaux Publics' added value in this market lies in its ability to design and build complex customised structures and its **recognised expertise** in maritime works. This ability is illustrated by the completion of emblematic projects, ranging from the floating hydrocarbon production barge *N'Kossa* (p. 50-51), the largest prestressed concrete barge in the world at the time of its construction, to the floating foundation of *Floatgen*, France's first floating offshore wind turbine (p. 52-53).

As each structure is unique, the expertise of our technical department allows us to adjust the dimensions of the design, both structurally and in terms of permissible movements under wave interaction. The proposed methods of construction, transport and installation are adapted to the budget and planning constraints of each project as well as to the environment in which the structures are installed. Our proficiency in the use of high-performance concrete with controlled density allows our teams to design and build **lighter and more durable structures**.

↓ Fécamp offshore wind farm [France]

FRANCE **1995**

N'Kossa Barge

Design, construction and delivery of a pre-stressed concrete barge for a hydrocarbon production unit

When she left the port of Marseille, where she was built in the spring of 1995, the *N'Kossa* vessel was the largest prestressed concrete barge in the world. A technical feat that took a year and a half to design, twice as long as the construction itself. Custom-designed to accommodate the world's largest floating hydrocarbon production unit, it is anchored at a depth of 170 metres off the Republic of Congo. Its design called for innovative approaches and methods never used before in this context. Some were inspired by the containment systems used in nuclear power plants, others by shipbuilding, all to ensure the **safety** and **watertightness** of the structure, particularly with regard to collisions with the outer hull, as well as its durability in the marine environment over a theoretical 30-year period.

LENGTH
220 m

WATER DEPTH
46 m

FRANCE **2017**

Floatgen

Construction of the foundations of the first floating offshore wind turbine in France

When *Floatgen* was set afloat 22 kilometres off the coast of Le Croisic in Brittany in August 2017, a new generation of offshore wind power emerged: the floating wind turbine. Installed on the SEM-REV test site of the École Centrale de Nantes engineering school, the first floating wind turbine in France, with a capacity of 2 MW, covers the equivalent of the annual electricity consumption of 5,000 inhabitants. Since 2013, this **experimental project** coordinated by BW Ideol has brought together seven European partners. Bouygues Travaux Publics produced the Damping Pool **floating foundation** patented by BW Ideol, using a specific formulation of lightweight concrete made from porous aggregates, in the port of Saint-Nazaire. A real technical feat, this square hull, measuring 36 metres on each side and 9.5 metres high, made of prestressed concrete, was lightened to weigh approximately 5,000 tonnes. The self-compacting concrete was poured in a homogeneous manner thanks to a pumping system. The structure then floated, when the barges on which it was built were ballasted. Connected to the national power grid, *Floatgen* has now been operational since September 2018.

FOUNDATION WEIGHT
5,000 t

TURBINE POWER
2 MW

FRANCE **2022**

Fécamp offshore wind farm

Design, construction and installation of 71 wind turbine foundations

The first Normandy offshore wind farm to be connected to the French electricity grid will be located between 13 and 22 kilometres off the coast of Fécamp. With a total capacity of around 500 MW, it is intended to produce the equivalent of the domestic electricity consumption of around 770,000 people. As part of this major project to diversify France's energy mix, Bouygues Travaux Publics is building the **gravity** base foundations, a technique used for the first time in France and adapted to the range of depths and geotechnical conditions in the area. The 71 prestressed concrete base structures, or GBSs, are being built on land, on the Bougainville quay within the Grand Port Maritime du Havre. The use of **four parallel production lines** as well as the movement of formwork tools and teams from one line to the other allow the industrialisation of the construction process of the GBSs. Once completed, the bases are placed on the barge through Kamags, and then placed on the seabed at a depth of 25 to 40 metres using a mega barge. With a unit weight of approximately 5,000 tonnes, they ensure the stability of the wind turbines after being filled with ballast material.

FOUNDATION WEIGHT
5,000 t

WATER DEPTH
25-40 m

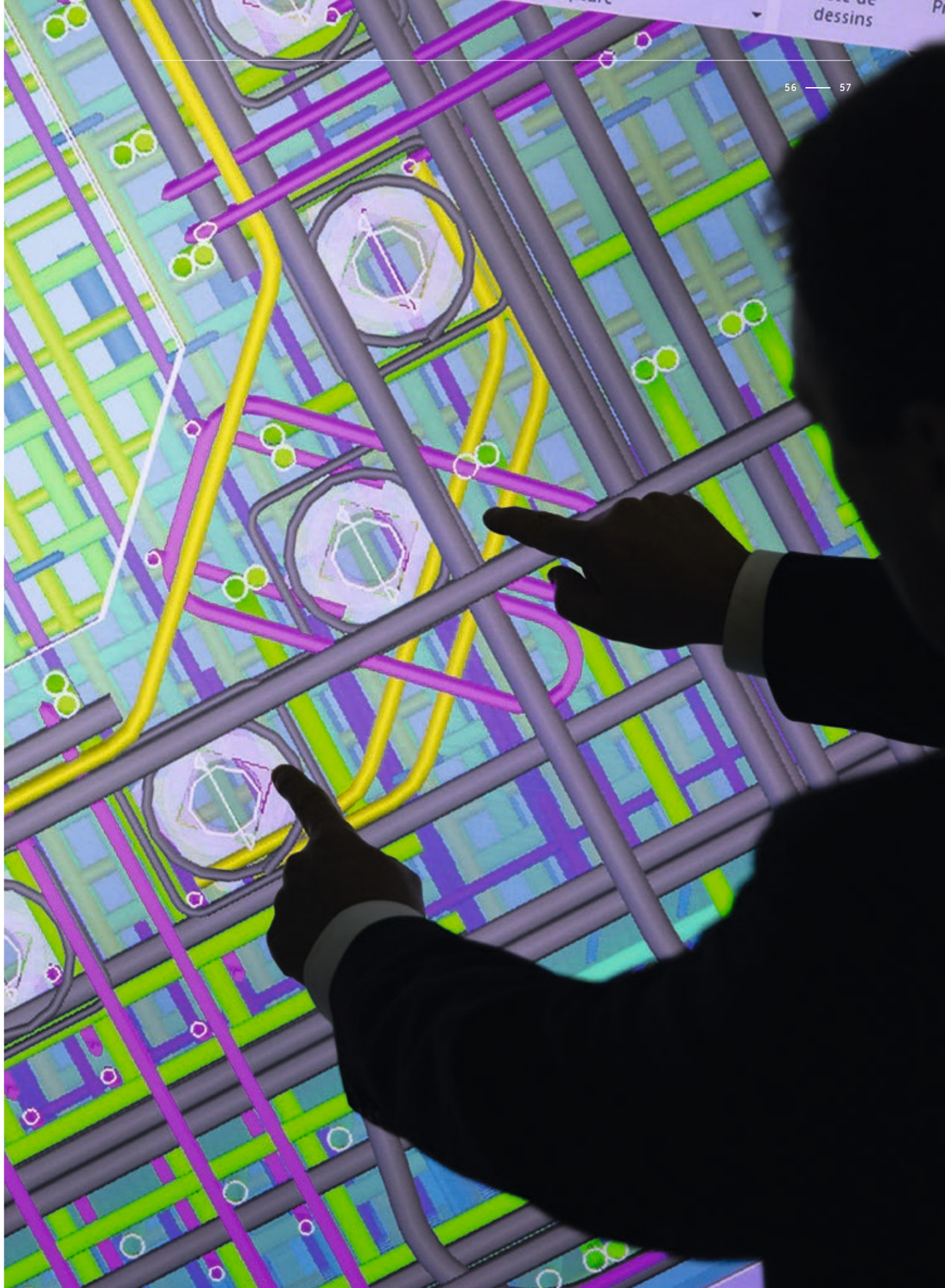
TURBINE POWER
7 MW

Shared innovation.

Innovation is at the heart of our culture and performance. Far from just being a trend, we are convinced that creativity, in the commercial phase or serving the work sites, is a competitive and technical factor that makes us stand out.

By building up a capital of ideas and by encouraging on-going improvement, innovation strengthens the reliability of our solutions, the quality of our structures and the safety of all those who work on our construction sites.

As players in the digital transformation, more than 600 engineers and technicians specialising in concept studies, detail design and methods as well as in R&D and creativity, are looking towards a more open and mobile world.



Innovation, why do we do it?

To adapt to the functional requirements of the structures

To reduce the environmental footprint of the works

To meet complex technical constraints

MARCO POLO +

A custom-made prototype

A floating and submersible production plant for the manufacture of caissons intended to form the protective belt of the Monaco offshore extension. The dock of this steel structure hosts the dry construction of the caisson's slab and then the continuous elevation of the external and internal walls by means of a sliding formwork. Once the walls have been raised to a height of 26 metres, the Marco Polo is ballasted with sea water. The platform then gradually descends underwater until the caisson **floats off**.

ZOURITE +

A unique mega barge

A self-elevating and self-propelled barge designed to meet the specific construction conditions of the New Coastal Road viaduct site on Reunion Island. Equipped with eight lifting legs with a unit capacity of 4,000 tonnes and two overhead travelling cranes with a lifting capacity of 2,400 tonnes each, *Zourite* is 107 metres long and 44 metres wide. It is used for **transporting** and **installing** land-built prefabricated elements. A **unique prototype**, this jack-up mega barge was designed so that it can be operational even in case of swells.

LOW-HEIGHT ANTI-OVERTOPPING STRUCTURES +

Protection of the coastal landscape

Design of low-level anti-overtopping sea walls compatible with demanding architectural constraints. The innovations implemented by the Bouygues Travaux Publics technical department in designing anti-over topping structures are the result of a combination of theoretical approaches, scale model tests and, over the past few years, **digital modelling**, which makes it possible to refine the concepts and optimise the sizing design of the structures. They include, in particular, the use of "Jarlan" type absorption chambers, perched chambers or wave traps as well as submerged platforms.

ECO-DESIGN +

Ecological engineering at work

Integration of environmental concerns from the design phase of a project and attribution of **new ecological functionalities** to the structures. The creation of artificial reefs by means of underwater hills, ecological installations on caissons and riprap, and two underwater villages made up of 250 eco-designed modules... The initiatives implemented on the Monaco offshore extension project or on the Viaduct of the New Coastal Road bear witness to the possibilities offered by eco-design in order to encourage the development of **biodiversity**.

We love life.

Protecting the health and safety of our staff,
as well as that of everyone else who works on our sites,
is our primary responsibility.

On all its construction sites, Bouygues Travaux Publics deploys the best worldwide standards while responding to the specific risks associated with river and maritime works: risks of falling into the water, slipping over on flat surfaces and falling objects, risks of electrocution, use of floating equipment, lifting operations, co-activity, operations in confined spaces, diving operations, work at high tide and at night, etc.

Safety is everyone's business: this means being vigilant at all times in order to ensure that our working methods are efficient and complied with.

Objective: Zero accidents.

- Training and empowering staff in order to limit high-risk behaviour
- Improving the ergonomics of work stations to reduce the occurrence of musculoskeletal issues
- Checking up on the efficiency of initiatives through an assessment system shared by the whole company

40%

of the training hours carried out in our training plan are devoted to health and safety.

HEALTH & SAFETY FUNDAMENTALS +

SAFETY CULTURE +

MARINE EMERGENCIES +

BRIEFING AND WARM-UP SESSION +

A high level of commitment

Protective equipment, traffic flow, risk analysis, ergonomics... Twelve standards applied on all Bouygues Construction worksites to ensure the safety of all. At Bouygues Travaux Publics, **organisational and preventive measures** specific to river and maritime works activities, such as the design of barges or pontoons with the presence of rigid collective protective measures, the drawing up of traffic flow plans, reinforced medical monitoring related to work at sea and training courses for the passage from a shuttle boat to a barge or a pontoon, complete this common set of standards.

A vision shared by all

Technical expertise, a management system and organisational and human factors, the safety culture is based on three inseparable factors with just one objective: to ensure that all the players in the company share the same **language** and the same **safety values**. During its 2019 Health & Safety Day, Bouygues Travaux Publics initiated a process of diagnosis and development of its safety culture with, in particular, implementing a specific management of major risks. This is an example of the company's commitment to reinforcing the safety of its staff.

Exclusive training course for machine operators

Pool exercises simulating a fall into the water from the cab of a machine. Designed for the Calais Port 2015 project, this training course aims to reproduce the **real conditions** of operators on site: with their eyes covered with a blackout mask to simulate a night or a cloudy water situation, the operator must manage to get out of the cab. Equipped with a construction helmet and a life jacket, they learn to use their **spare air**, a reserve of air lasting a few minutes, and to handle the impulse window breaker. This course is **mandatory**. If they fail, the operators concerned can only work on land.

Starting the day safely

A daily team **warm-up session** to get muscles moving so as to reduce musculoskeletal problems. This new practice, coupled with a briefing presenting the jobs to be done during the day and things to watch out for, gets the body and the mind ready for the start of a shift and prevents sprains and stiffness whilst reinforcing team cohesion.

A subsidiary of Bouygues Construction specialised in civil engineering and related works, Bouygues Travaux Publics is **a global leader in the construction of sustainable public infrastructure enhancing regional development.**

TUNNELS
& UNDERGROUND
STRUCTURES

RIVER &
MARITIME WORKS

BRIDGES, VIADUCTS
& FOOTBRIDGES

INDUSTRIAL
CIVIL ENGINEERING

LINEAR
PROJECTS

REFURBISHMENT &
REINFORCEMENT
OF STRUCTURES

EARTHWORKS

OPEN
CAST MINING

Holding back the winds and tides was designed and written by the Bouygues Travaux Publics Communications Department.

Publishing director · Philippe Amequin

Production · la nouvelle

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Shared **innovation**