

From one side to the other.

BRIDGES, VIADUCTS & FOOTBRIDGES



Shared **innovation**



The strength of experience.

For more than 35 years, Bouygues Travaux Publics has been a recognised player in the civil engineering structures market. Our business lines cover the design, construction, reinforcement and renovation of bridges, viaducts and footbridges.

Proficient in the entire range of construction techniques, we have based our reputation on our ability to build iconic structures and to design customised tools and equipment to adapt to the natural constraints of the site.

By relying on synergies created with VSL International, a Bouygues Construction subsidiary which has unique knowledge of prestressing and cable-stay systems, Bouygues Travaux Publics is committed to collective intelligence and provides its expertise across the entire value chain of the construction industry.

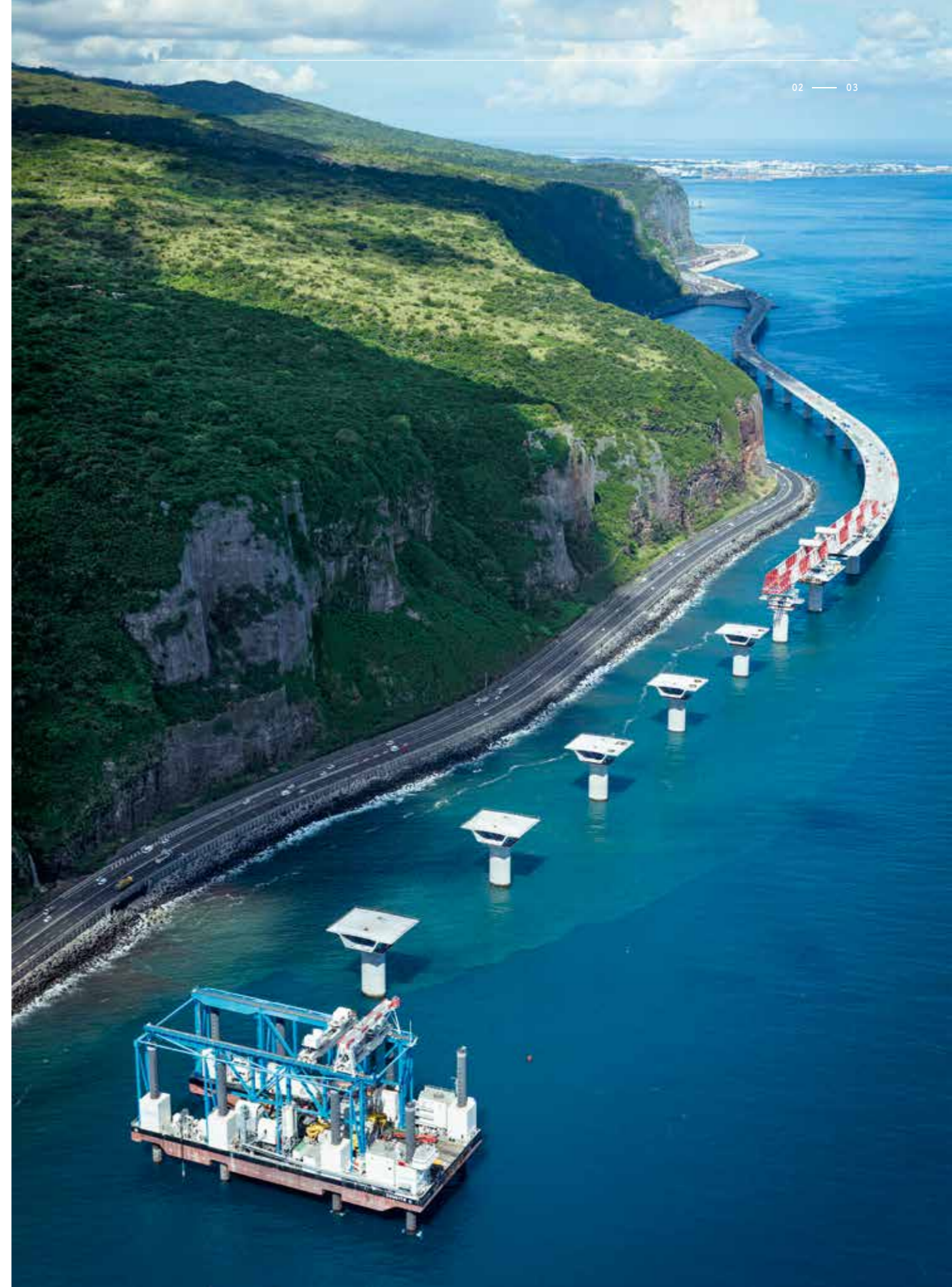


Standing up to the test of time.

Hong Kong, Paris, Abidjan, Seoul, Lyon... Bouygues Travaux Publics has built more than a hundred non-standard bridges of all types over five continents: arch bridges, bowstring girder bridges, cable-stayed or suspended bridges, box girder bridges, composite steel concrete bridges and lift bridges.

Bridges of all dimensions: from standard single-span projects up to the 5,409 metres of the longest sea viaduct in France. Bridges for all uses: linking people and places, relieving congestion in towns and cities, encouraging eco-friendly transportation, improving the efficiency of public transport and goods traffic.

We are now ready to rise to the challenges of the future: building in dense urban environments, designing floating structures, developing very long span bridges. As a responsible builder, we are constantly improving the durability and optimisation of civil engineering structures in order to conserve resources and minimise humankind's impact on its environment.





The Engineer's art.

Bridges and viaducts give shape to our lands. In the search for technical excellence and a sense of aesthetics: engineers and architects combine their know-how to blend every structure into its environment.

When crossing a natural obstacle or a land, river or sea traffic route, the parameters for deciding on the best technical solution are many and variable.

Thanks to its in-house engineering department, Bouygues Travaux Publics has the necessary technical expertise to offer its clients the technical variants that best meet their needs.



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

Construction using form travellers

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Form traveller construction often represents the most appropriate and cost-effective solution for the construction of **large span concrete** structures. It is generally associated with the **balanced cantilever construction technique** when segments are cast on-site and not prefabricated.

This method does not necessitate any temporary support as it involves on-site construction, phase by phase:

- ⊙ **A pair of form travellers is fixed on either side of a pier.**
- ⊙ **Formwork, on each traveller, enables each segment or deck section to be cast.**
- ⊙ **Once the resistance of the concrete has been reached and prestressing has been carried out,** the travellers are moved and fixed onto each poured segment on either side of the pier until the mid-span is reached where a stitching section is cast.

Thanks to the expertise of the Bouygues Travaux Publics teams, form traveller construction has enabled the building of iconic structures for which the height of the gap and the topographical or geotechnical conditions were significant constraints in the construction process. This method has also been applied to the construction of single-arch bridges with form travellers being mounted directly onto the abutments, as was the case for the Bras-de-la-Plaine Bridge (p.10).





FRANCE 1991

Viaduct over the Isère

Construction of the first cable-stayed bridge of the French motorway network

 TYPE
CABLE-STAYED
BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
148 m


One of the six non-standard engineering structures on the A49 motorway linking Grenoble to Valence and the Valley of the Rhône, the Isère Viaduct was, when under construction, the first long span cable-stayed bridge in the French motorway network. With a steep slope on the left bank side and a gap formed by the Isère Gorge and rail tracks and a road, the topographical features led to the construction of a **dissymmetrical cable-stayed bridge**. A single 148-metre span enables the river and the left bank slope to be crossed. 306 metres long, the prestressed concrete bridge was built using the **balanced cantilever technique** from the single 94.8-metre pylon. Each 8-metre segment was cast in five phases, with the final cable stay being used to take the weight off the form traveller in the provisional phase. The cable stays, arranged perfectly in a fan shape, are deviated at the top of the pylon by a steel saddle. At the beginning of the 2000s, renovation work on the bridge was undertaken with the addition of a protective HDPE sheath around each cable-stay.



FRANCE 2000

Pont-Salomon Viaduct

Execution of the doubling up and repair work on an existing structure

 TYPE
BOX GIRDER
BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
69 m

Twenty-one years after the opening to traffic of an overpass on the RN 88 road linking Lyon to Toulouse which bypasses Pont-Salomon in the Haute-Loire region, a new structure **parallel** to the first road was built to improve this main road by doubling the existing traffic lanes. 505.5 metres long, this **prestressed concrete box girder** viaduct follows the outside curve of the original structure perfectly. Consisting of eight spans, it was built with the balanced cantilever technique using form travellers. Constructed in just 14 months thanks to the mobilisation of five cranes and two pairs of formwork travellers, the Pont-Salomon Viaduct is the first French structure designed and calculated according to the European calculation standards of Eurocodes 1 and 2. In addition to the construction of the new viaduct, repair work was carried out on the initial structure: waterproofing of the slab, repair of damaged concrete and water collection and drainage of the deck.



REUNION ISLAND 2001

Bras-de-la-Plaine Bridge

Bridge construction with the balanced cantilever method

 TYPE
ARCH BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
280 m

The volcanic origin of what used to be known as l’île Bourbon means that the very rugged terrain greatly hinders travel. Bouygues Travaux Publics built a road link between the municipalities of Saint-Pierre, a large town in the south of the island, and the commune of Entre-Deux for Reunion Island’s General Council. Crossing the Bras-de-la-Plaine river by spanning the valley at a height of 110 metres, the bridge is designed as a single **arch** of 280 metres, without piers or pylons that might detract from the wild aspect of the gully. It sets a **world record** for a structure with a composite steel-concrete deck. With a total length of 350 metres, the structure is made up of a deck consisting of two thin slabs that are connected by steel tubes fitted with prestressing cables. The structure was built using the balanced cantilever technique with specially designed made-to-measure formwork travellers. The Bras-de-la-Plaine Bridge received the IABSE Outstanding Structure Award in 2003.



FRANCE 2012

Saint-Gervais-les-Bains Viaduct

Construction of an arch-shaped bridge

 TYPE
ARCH BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
170 m

Since 2012, the Saint-Gervais-les-Bains Viaduct has provided a breathtaking view of the Mont-Blanc massif. Above all, it helps to **relieve the traffic congestion** in the town of Saint-Gervais, which is gridlocked during the winter season by traffic of some 15,000 vehicles a day. 90 metres above the Bonnant gap, the 240-metre-long viaduct has a 170-metre central span **without support** thanks to a deck design combining two prestressed concrete slabs connected by steel diagonals. The work was carried out using the balanced cantilever technique with a specially designed form traveller. The supports are seated on piles, deep-shaft “Moroccan” piles, or on a surface footings. Built on an all trades basis for the Haute-Savoie Departmental Council, this remarkable structure blends seamlessly into the panorama of the Aravis mountain range, now listed as a nature reserve.

SOUTH AFRICA 2011

Gautrain Rapid Rail System

Construction of railway viaducts
for a concession project

Delivered on schedule for the FIFA World Cup, the high-speed railway line from Pretoria to Johannesburg was the completion of the most significant **PPP** project in which Bouygues Travaux Publics has taken part on the African continent. 54 months of work, 15 kilometres of tunnels excavated, 10 stations built and 10.5 kilometres of bridges: this colossal project was also the first integrated rail project undertaken by Bouygues Travaux Publics. The **thirteen** viaducts were designed according to the same general plan and entirely made of concrete. However, the construction methods used were quite varied. For example, two viaducts of 110 metres and 121 metres for the main spans were built of cast-in-place concrete with the balanced cantilever method using form travellers, a solution that was unique in South Africa at the time. Nine other viaducts were assembled using prefabricated segments. The last two are based on prestressed prefabricated girders with cast-on-site concrete slabs.

 TYPE
BOX GIRDER
BRIDGE

 USE
RAIL



Construction using launching gantry

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Invented in 1941, the launching gantry is a technology that makes it possible to build engineering structures without falsework support between piers. Since the construction in less than 23 months, of the Ile de Ré Bridge, the longest bridge in France in 1988, Bouygues Travaux Publics has favoured this construction technology on **long structure** projects with **repetitive spans**. Associated with **prefabrication**, construction using launching gantry significantly reduces building time, environmental impacts

and the traditional need for lifting and handling equipment.

⦿ **The segments are prefabricated** on the ground.

⦿ The launcher rests on the finished cantilevered deck section and on the next pier. The prefabricated segments are brought to their final location using **overhead cranes**.

⦿ **The segments are then fixed in place** and grouted to form a completed cantilevered deck section.

⦿ **Once the cantilevered deck section has been completed and stitched to the previous section, the launching gantry moves autonomously towards the next pier.**

Our know-how is based on the experience of our technical and equipment departments, which are capable of guaranteeing the quality of segment manufacture and designing and implementing tailor-made **equipment** that is suited to meeting the constraints of the works.





FRANCE 1998

Avignon Viaducts

Construction of two parallel railway viaducts crossing the Rhône river

In 1998, after 36 months of works, Bouygues Travaux Publics delivered the dual viaduct of Avignon, which allows the Rhône to be crossed by the TGV Méditerranée high-speed train line serving Avignon train station. These two parallel structures are 1,500 metres long and rest on 40 fifty-metre-high piers. 838 segments, each weighing from 110 to 145 tonnes, laid using the balanced cantilever technique, make up the 39,000-m² of the deck prefabricated on-site using the **bonded joints method**, which makes it possible to adjust the deck. They were designed to be able to withstand extraordinary **loads**: the emergency braking of a train travelling at 350-km/h or the impact on a pier of a boat sailing on the Rhône. In order to slim down the shapes of the spans, the viaducts are made up of geometrically variable segments whose height gradually decreases from the support towards the middle of the span. Designed with posterity in mind, the Avignon Viaducts blend perfectly into the landscape thanks to their white cement concrete, reminiscent of the limestone of the Angles massif and the immaculate colour of the walls of the Palace of the Popes.

 **TYPE**
BOX GIRDER
BRIDGE

 **USE**
RAIL

 **MAXIMUM**
SPAN
100 m



FRANCE 1999

Saint-André Viaduct

Construction of a 2 x 2-lane motorway viaduct

-  TYPE
BOX GIRDER
BRIDGE
-  USE
ROAD
-  MAXIMUM
SPAN
95 m



Following the route of the Maurienne motorway, the Saint-André Viaduct is seated in the bed of a torrent at an altitude of 1,000 metres, in a valley bottom subject to seismic activity and the harsh alpine climate. The narrowness of the site made it necessary to build this **motorway bridge**, which is 904 metres long, with a standard span of 95 metres. The deck is made of prestressed concrete: it is a **single concrete box** specifically formulated to resist frost and de-icing salt, of constant height, varying from 22 to 27 metres in width and transversely prestressed. The deck was built using the balanced cantilever method with prefabricated segments placed by a launching gantry. The prefabrication of the segments for the construction of the deck eliminated any disruption to traffic during the construction phase, avoided the issues associated with the Arc river and minimised the impact of the harsh winter weather as the components were made in a hangar.



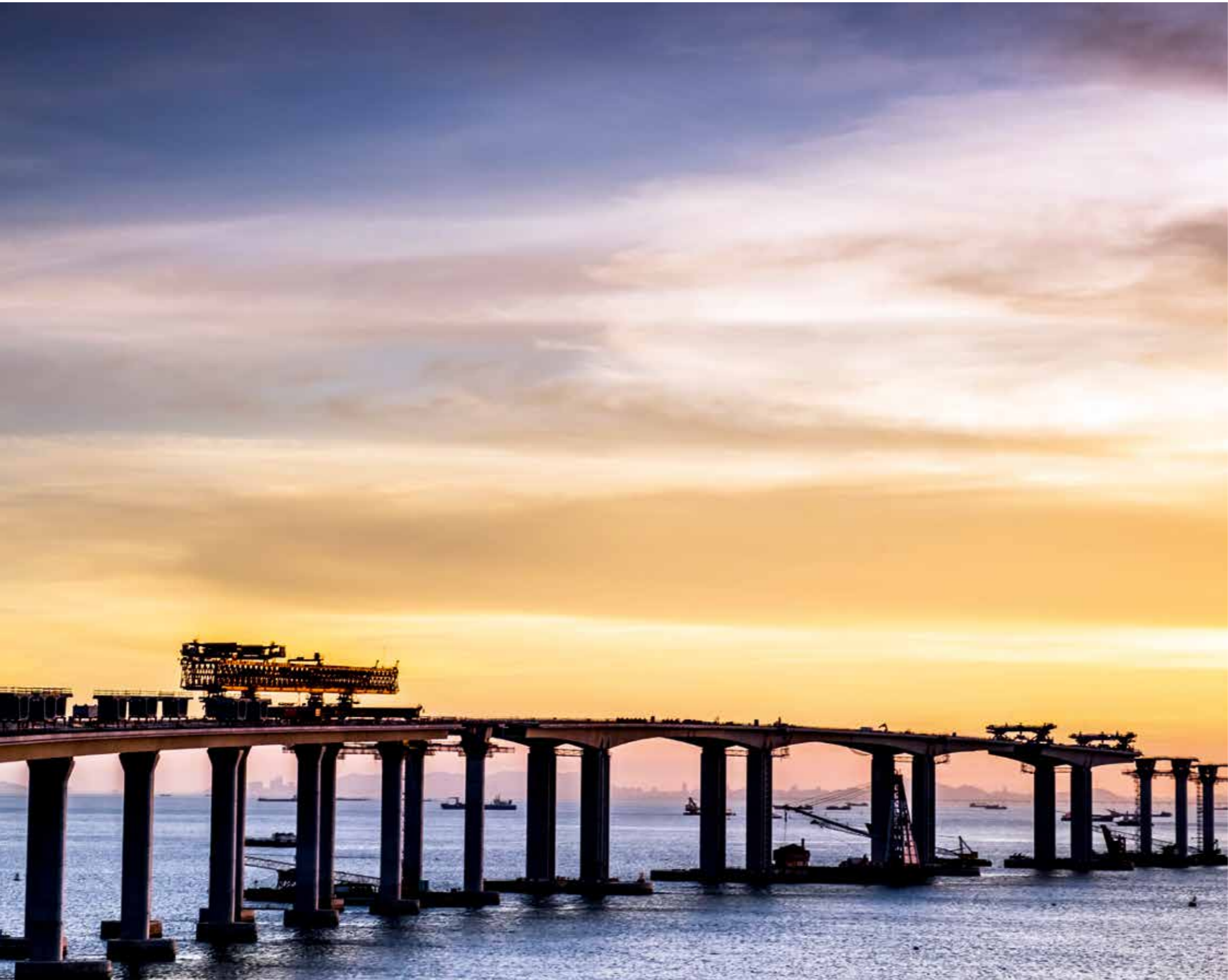
HONG KONG 2008

East Tsing Yi Viaduct

Construction of a main viaduct linking the Stonecutters Viaduct to the Nam Wan Tunnel

-  TYPE
BOX GIRDER
BRIDGE
-  USE
ROAD
-  MAXIMUM
SPAN
84 m

The East Tsing Yi Viaduct, an iconic structure built by Dragages Hong Kong and Bouygues Travaux Publics in a joint venture with the Chinese constructor China Harbour Engineering, is an essential link in the main road linking the city of Shatin to Hong Kong International Airport. Its construction required the implementation of appropriate methods and equipment. The 1,939 segments that make up the 1.25-km long main deck were all prefabricated on the mainland in China, then delivered by **barge**. Similarly, a custom-built launcher, 150 metres long and weighing more than 700 tonnes, was designed to enable the installation of **highly curved** spans (starting with a radius of 125 metres) at a height of 40 metres. To this day the viaduct still allows traffic to flow freely around one of the largest container ports in the world.



CHINA 2018

Hong Kong-Zhuhai-Macao Bridge

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

The Hong Kong-Zhuhai-Macao Bridge is a 42-kilometre-long stretch of structures that is part of a 55-kilometre motorway project spanning the Pearl River estuary in the South China Sea. This outstanding infrastructure project is set to accelerate trade throughout the region. 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 some 5,714 prefabricated segments. The structure broke the world record for the largest span ever made of prefabricated segments: a 180-metre span with a curve radius of 513 metres. 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.

 TYPE
BOX GIRDER
BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
180 m

REUNION ISLAND 2019

Coastal viaduct

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

Designed to keep cars 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 over the water 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. 95% of the components of the bridge were **prefabricated** on land in two prefabrication plants and then installed by sea or by a launching gantry. For offshore operations, a single mega barge was specially equipped for coastal navigation in difficult seas. It was fitted with two overhead cranes and a concrete plant, *Zourite* 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**.

TYPE
BOX GIRDER
BRIDGE

USE
ROAD

MAXIMUM
SPAN
120 m



Construction by **lifting**

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Since antiquity, winch and pulley gantries have been used to lift stone blocks and build bridges and viaducts. Nowadays, in combination with the prefabrication of segments or complete spans, construction by lifting is suitable for engineering structures of **all types** (bowstring girder, box girder and cable-stayed bridges). When site accessibility conditions allow, this technique makes it possible to build large structures, with reduced methods engineering resources, while multiplying the number

of segment fitting points. It differs from construction using a launching gantry in its greater simplicity of execution:

⦿ **The prefabricated components are brought to the site by land, river or sea.**

⦿ **Using lifting jacks, cranes placed on the ground, on a barge or on a constructed part of the structure, the components are lifted and then put in place.**

As each engineering structure is unique, the added value of Bouygues Travaux Publics lies in its ability to optimise assembly cycles associated with standardised lifting equipment as well as in its ability to design and build customised **lifting systems** that are suited to the specific conditions of the project. The *Zourite* self-elevating mega-barge, used on the New Coastal Road Viaduct on Reunion Island, is a perfect illustration of our technical department's capacity for innovation, serving the client and the project.





FRANCE 2006

Gustave-Flaubert Bridge

Construction of a lift-bridge over the Seine

TYPE
LIFT BRIDGE

USE
ROAD

MAXIMUM
SPAN
120 m

Remarkable both in terms of its dimensions and its technical characteristics, the sixth bridge over the Seine was also the largest **lift bridge** in Europe at the time of its inauguration. Composed of two mobile decks and six traffic lanes, it is inserted in the middle of a 670-metre viaduct and aims to divert road traffic from Rouen city centre by linking the A13 and A29 motorways. The two independent decks rise up to 55 metres high along four piers to allow the passage of cruise liners and old-time tall sailing ships. The 450-ton steel structures supporting the pulleys that lift the bridge were installed on the pylons at a height of 70 metres by a **floating crane**. These steel trusses, known as “butterflies”, support the metal spans, each weighing 1,250 tonnes, and measuring 120 metres long and 17 metres wide. At the foot of the structure, circular reinforced concrete protective blocks – known as gabions – protect the bridge against possible impacts from boats.



SOUTH KOREA 2008

Masan Bay Bridge

Design, construction, operation and maintenance of a cable-stayed bridge and two access viaducts as part of a concession project

TYPE
CABLE-STAYED
BRIDGE

USE
ROAD

MAXIMUM
SPAN
400 m

The first public-private partnership in South Korea led by a foreign investor, the Masan Bay Bridge is a new access road to Pusan, the country’s second largest industrial centre. This toll-road bridge consists of a 740-metre cable-stayed central section and two access viaducts, all linked by a composite steel and concrete deck. Its construction combined the launching method, balanced cantilever and **lifting techniques** in an area subject to winds of up to 250-km/h. The deck of the cable-stayed bridge was prefabricated with steel segments lifted from a barge using a **crane on the deck under construction**. The consortium comprising Bouygues Travaux Publics and Hyundai Engineering & Construction is responsible for operating and maintaining the built structures for 30 years.

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

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. 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. **Blank 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.

 **TYPE**
BOX GIRDER
BRIDGE

 **USE**
ROAD

 **MAXIMUM**
SPAN
50 m







FRANCE 2014

Raymond-Barre Bridge

Construction of a viaduct crossing the Rhône river




-  TYPE
BOWSTRING
BRIDGE
-  USE
ECO-FRIENDLY
MEANS OF
TRANSPORT
-  MAXIMUM
SPAN
152 m

A 2,500-tonne central deck placed on two support piers to span one of the largest rivers in Europe: this is the achievement of the Raymond-Barre Bridge which, since 2014, has linked Confluence and Gerland, the two booming districts of the city of Lyon. Exclusively dedicated to eco-friendly modes of transport, this **radiating arch** bridge is made up of three spans with a total length of 263 metres. Hemmed in on both banks by existing buildings, the bridge is positioned at an angle to the river's axis. Located in the middle of the Rhône and completely submerged, the central pier of the main span was erected in a cofferdam 15 metres deep. In order to ensure the continuity of navigation on the Rhône and to restrict the site's footprint, the bridge deck could neither be poured on-site nor prefabricated on the river's banks. Assembled at Port Édouard-Herriot, the deck was then transported and installed using **barges**.

FRANCE 2015

Beatus-Rhenanus Bridge

Construction of a bowstring arch bridge across 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 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 routes. It crosses a 240-metre **river gap** with a clearance of 7.5 metres and rests on a single pier in the middle of the river with two supports 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 main decks required a great deal of technical expertise: levelling the deck on the river 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.

Construction by incremental launching

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Construction by incremental launching can be applied to **concrete** and **steel** structures respectively. This construction method, which has been used since the 19th century for steel structures, is recommended when the installation of falsework is not feasible, in particular due to the lack of ground space at the level of the gap or for spans exceeding 100 metres. This is frequently the case for motorway or river crossings. The operation consists of moving the deck along the axis of the bridge:

⦿ **The deck is manufactured in successive sections in a specially set aside area.**

⦿ **As the sections are manufactured, they are pushed or pulled by means of jacks or cables.**

⦿ **The deck moves forward over the gap, being supported on successive piers until it reaches its final position.**

⦿ **Temporary stay cables or support piers are used with a launching nose to facilitate docking on the piers.**

Our experience is based on an in-depth knowledge of push kinematics and highly proficient knowledge of launching and guiding **systems**. Site installations are optimised to ensure the repeatability and quality control of operations. Over more than 35 years, Bouygues Travaux Publics teams have demonstrated their creativity by patenting the lift-launch method on the Normandy Bridge, or by proposing installation by rotation or **sliding** when the site presents significant operating constraints.





FRANCE 1995

Normandy Bridge

Construction of a cable-stayed bridge across the estuary of the Seine

 TYPE
CABLE-STAYED
BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
856 m


When it was inaugurated in 1995, the Normandy Bridge was the largest **cable-stayed bridge** in the world. Crossing the Seine estuary in one go over a distance of 2.14 kilometres, this French structure links the industrial centre of Le Havre to the tourist bank of Honfleur. It extends its mixed span over 856 metres in a zone swept by winds that can exceed 100-km/h. The choice of a cable-stayed bridge was an economical and aesthetic solution that overcame the limitations imposed by the site: a conventional bridge would have required the presence of supports that would have been resistant to boat impact; a suspension bridge would have generated significant additional costs related to its maintenance. To cross a 6% slope, the concrete decks of the north access viaduct had to be installed using a new technique patented by Bouygues at the time: the so-called **lift-launch method**. Today, this iconic structure is a major transport route that contributes to the economic development of the region.



FRANCE 1996

Charles-de-Gaulle Bridge

Construction of a composite deck bridge over the Seine

 TYPE
BOX GIRDER
BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
84 m

Approved in 1986 by the Paris Council as part of the construction of new road infrastructure, the construction of the Charles-de-Gaulle Bridge was carried out in a very constrained environment. Designed by the architect Louis Arretche, a great urban planner of the post-war years, the bridge rises to the challenge of blending in by preserving the unique site of the river and access to the river banks. Its **aeroplane-wing-shaped profile** is a contemporary counterpoint to the Austerlitz Viaduct. This composite bridge deck consists of a prestressed concrete slab and a steel framework and is one of the most recent bridges built in the capital. With a length of 207 metres, it connects the Quai d'Austerlitz to the Quai de la Rapée, opposite the Gare de Lyon, via six traffic lanes. The deck is supported by two lightweight corolla-shaped piers made of polished white concrete and two concrete abutments. Composed solely of its load-bearing caissons to reduce its weight, the deck was erected with a **launching nose**.



FRANCE 2001

Garrigue Viaduct

Construction of a motorway viaduct

 TYPE
COMPOSITE
STEEL
CONCRETE
BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
74 m


The Garrigue Viaduct, of classic composite construction, is one of the three **non-standard structures** bypassing the Aveyron sub-prefecture. It allows the A75 motorway, linking Clermont-Ferrand to Béziers, to cross the Garrigue ravine in the commune of Verrières. The structure extends over a length of 340 metres spread over five spans with a maximum length of 74 metres. Its two adjoining decks were erected by launching with a launching nose without a temporary support pier. Seated on surface footings or deep “Moroccan” shafts, the piles have a recessed pattern on them up to 58 metres in height to emphasise their slenderness. The originality of this structure lies in the use, for the first time in France, of **high-yield strength steels**. These steels, obtained by adding microalloy components, have better strength, deformability and weldability than those richer in carbon.



FRANCE 2005 and 2007

Palays Interchange - phases 1B and 1C

Construction of two viaducts and a concrete slab as part of the reconfiguration of a motorway interchange

 TYPE
BOX GIRDER
BRIDGE

 USE
ROAD

The Palays motorway junction, a converging point of the south-west motorways and the roads linking Toulouse to the Technopole, was experiencing increasingly heavy traffic. The vast **redevelopment works** carried out between 2002 and 2007 responded to two challenges: to make through traffic more fluid and to facilitate the daily journeys of the region’s inhabitants. The first phase (phase 1B) consisted of the construction of a 249-metre-long **composite segment viaduct** and connections to existing roads. The 720-tonne box girder was launched in four phases and the concrete slab was poured in place using two form travellers. In the second phase (phase 1C), two structures were added to the construction: a prestressed concrete slab bridge over the A61 motorway and a mixed box-girder deck viaduct over the River Hers. While the first was partly pushed into place, the second was launched from both ends with a crane-laid central span.



FRANCE 2008

Grand pont sur la Loire

Construction of a suspension bridge over the Loire River

-  TYPE
SUSPENSION
BRIDGE
-  USE
ROAD
-  MAXIMUM
SPAN
200 m

Built during the diversion of the RD 498 road, this major structure spans the Loire at Saint-Just-Saint-Rambert, 15 kilometres north of Saint-Étienne. Designed with a **suspended deck** with a composite steel-concrete structure, it crosses the river in a single 200-metre span without any intermediate support, a solution chosen to preserve the biotope and the vegetation on the edge of a sensitive ecosystem. The suspension system is **self-anchored** by means of large blocks acting as counterweights. This solution avoids having to use tie rods, which are incompatible with the geotechnical characteristics of the banks of the Loire. The pylons, for their part, are in the shape of an inverted V. Because of their inclination and variable thickness, their legs were made using a special **climbing formwork** system designed by the methods department.



FRANCE 2019

Guerville Viaduct

Construction of a third motorway deck and its connections to the south of the two existing decks

-  TYPE
COMPOSITE
STEEL
CONCRETE
BRIDGE
-  USE
ROAD
-  MAXIMUM
SPAN
116 m

As part of a major motorway revival plan, on a particularly dense section of the A13 motorway, Bouygues Travaux Publics built a third deck for the Guerville Viaduct to enable the two existing decks to be renovated by temporarily shifting traffic. Ultimately, this viaduct, consisting of a steel-concrete **composite structure** with a 3,000-tonne steel framework, will also help to ease traffic flow by creating an additional lane for journeys between Paris and Caen. It is a highly complex project, operating above or near **active rail and road traffic lanes**. The installation of the 360-metre-long deck thus required no fewer than three launching operations. To enhance the safety of the teams, several systems were put in place, such as a sliding tool to prefabricate all the reinforcement mesh sheets at the extremities of the viaduct.

FRANCE 2017

Nîmes-Montpellier bypass

Construction of a railway viaduct as part of a public-private partnership contract

The Nîmes-Montpellier bypass is a unique project: carried out as part of a public-private partnership contract, it includes the financing, design, construction and maintenance of 80 kilometres of **mixed line**, including 60 kilometres of high-speed line between Manduel and Lattes. This operation involves the construction of 185 engineering structures, the largest of which are designed to ensure minimum disturbance of the watercourses crossed. In conjunction with *Réseau ferré de France*, special attention was paid to several biodiversity hotspots and ecological corridors along the line's route. An **environmental observatory** and measures to preserve protected heritage species also helped to limit the impact of the worksite on its environment.

USE
RAIL



Construction on falsework

• • • • •

Construction with falsework is the most common technique for building a bridge, footbridge or viaduct and our teams are highly proficient at it.

⦿ The falsework provides a support for the formwork or prefabricated components.

⦿ The structure being built rests on it.

⦿ It can be replaced by a conventional shoring or a lifting system (p. 24-25).

The structure is then built in a single phase on general falsework, running across the entire width of the gap, and will be removed once the work is completed. This simple construction method can be generalised to multi-span structures built in phases,

by reusing basic falsework, or by sections allowing multiple work fronts. This construction technique is particularly suitable for arched structures. With our long-standing expertise in falsework construction, our know-how in this field is based on total control of the stability and deformability of the load-bearing structure during all phases of the works.





FRANCE 1997

Savoie Viaduct

Construction of a three-span arched viaduct linking Savoie to Isère

 TYPE
ARCH BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
74 m

To cope with the increase in traffic between Savoie and Isère and with town centres unsuited to such traffic in the communes of Pont-de-Beauvoisin, an alternative solution to the single bridge over the Guiers was decided on by the general councils of the two departments of the Auvergne-Rhône-Alpes region. Located upstream from the conurbation, the Savoie Viaduct links an Isère cliff to a Savoyard plain with a **7% slope**. 175 metres long, this concrete viaduct consists of **three arches**. Its last arch, whose span measures 73.80 metres, crosses the river in a single go. The deck is supported by small piers spaced 8.20-m apart, each of which supports a crossbeam.



SOUTH KOREA 2002

Seonyu Footbridge

Construction of an arch-shaped footbridge

 TYPE
ARCH BRIDGE

 USE
PEDESTRIAN

 MAXIMUM
SPAN
120 m

Designed by architect Rudy Ricciotti, the Peace Bridge (its original name) links the South Korean capital to the island of Seonyu, which was transformed into an urban park for the 2002 Football World Cup. The structure, built by Bouygues Travaux Publics and VSL Korea, a subsidiary of Bouygues Construction, used, for the first time in the world, **Ductal**, an ultra-high-performance fibre-reinforced concrete developed in collaboration with the cement manufacturer Lafarge, and Rhodia, a specialist in the chemical industry. This innovative material provides very high compressive strength and is resistant to abrasion and pollution. Offering the same load-bearing capacity and resistance as conventional concrete, Ductal makes it possible to halve the amount of material used and thus to design structures of great **finesse** and unparalleled strength. The pedestrian footbridge consists of a slender arch with a span of 120 metres and a thickness of just 3 centimetres, to which two metal access walkways are attached.



FRANCE 2004

Anguienne Viaduct

Construction of a prestressed concrete bridge as part of the Angoulême eastern bypass

To cross the Anguienne, a tributary of the Charente that runs along the eastern contours of the town of Angoulême, not one arch but **two half arches** were designed by the architect Charles Lavigne. Limiting as much as possible the impact on a protected natural environment, the structure makes its two arches meet at a height of 15 metres before allowing them to lean horizontally against the slopes. The structure sacrifices neither solidity nor aesthetics to blend as naturally as possible into the landscape. The 100% concrete viaduct, 403 metres long and 11 metres wide to allow for two traffic lanes, has a central deck made of ribbed prestressed concrete supported by eight small piers of variable height. The design of the structure, remarkable for its boldness, led to technical challenges and innovative solutions. Bouygues Travaux Publics Régions France designed special formwork tools and a **mobile platform** that can be adapted to the three radii of curvature of the arches.

 TYPE
ARCH BRIDGE

 USE
ROAD

 MAXIMUM
SPAN
195 m

Renovation, restoration and reinforcement of bridges

• • • • •

Steel bridges, reinforced and prestressed concrete bridges, composite steel-concrete bridges: civil engineering structures, whatever their construction method, undergo transformations over time. The ageing of the materials of which they are made, and the evolution of the constraints to which they are subjected, justify appropriate maintenance. Repairing, reinforcing and adapting the existing heritage thus represent a considerable technical and economic challenge.

At a time when a region's dynamism depends in part on the quality of its transport infrastructure, Bouygues Travaux Publics offers, under the VSL France brand, an **integrated service** for monitoring, repairing and reinforcing engineering structures:

⦿ **Concrete repair and protection.**

⦿ **Reinforcement with composite materials.**

⦿ **Reinforcement by additional prestressing.**

⦿ **Computer-assisted jacking.**

⦿ **Replacement of support devices.**

⦿ **Upgrading of safety systems.**

In this restoration market, Bouygues Travaux Publics provides its expertise in terms of risk management and working on **occupied sites** under severe operating constraints. By managing all the interfaces, we ensure the consistency of the entire project for our clients.





FRANCE 2009

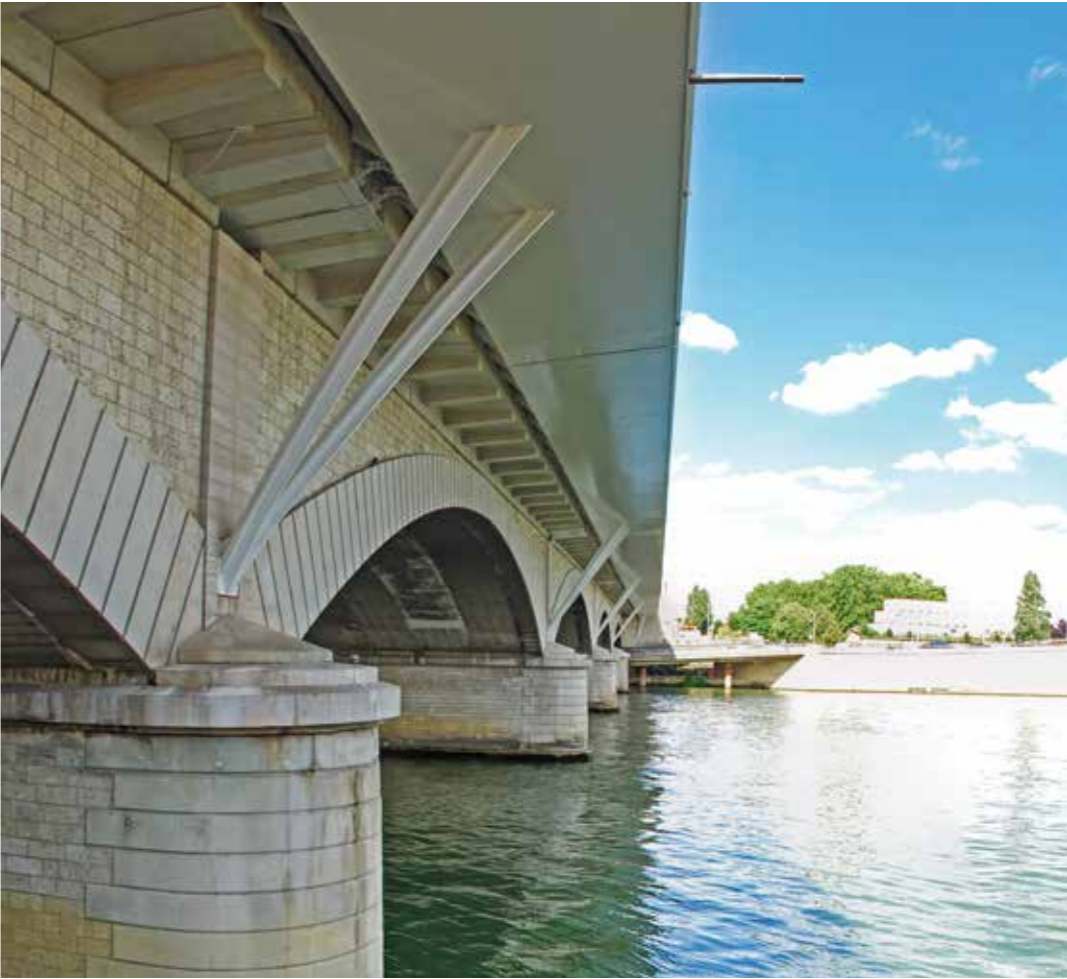
President John-Fitzgerald-Kennedy Coastal road

Execution of repair work on prestressed structures and supports of the coastal road

TYPE
CANTILEVERED
STRUCTURE

USE
ROAD

An iconic road on the Marseille coast, the Corniche Kennedy suffers from repeated attacks of **sea spray** and sea air on its reinforced concrete structure. After renovation work begun in 1999 to make the surface more watertight and consolidate part of the viaducts, a new restoration programme was launched in 2008 on the four remaining structures and corbel supports: reinforcement by additional prestressing, repair of the concrete and repair of other equipment. In 2018, new repair and reinforcement work again started to be undertaken on the part of the road above the sea: repair and reinforcement of the reinforced concrete brackets, replacement of the existing parapets and benches with new ultra-high-performance fibre-reinforced concrete (UHPC) elements containing organic fibre and replacement of the existing slabs with new prefabricated ones. The reinforcements of the concrete brackets were protected by the putting in place of an impressed current **cathodic protection** system.



FRANCE 2012

Pont National

Widening of the Pont National as part of the extension of the T3 tramway line

TYPE
ARCH BRIDGE

USE
ROAD AND
ECO-FRIENDLY
TRANSPORT


The widening of the Pont National was an opportunity to embellish and **reinforce** this structure built in 1852 and 1853 by the engineers Couche et Petit. 188.5 metres long and 34 metres wide, the Pont National is an essential transportation artery for the capital's 12th and 13th districts. It comprises, downstream, a masonry structure carrying the Petite Ceinture (Little Belt Railway) and, upstream, a reinforced concrete structure carrying the Boulevard des Maréchaux ring road. The operation consisted of modifying the profiles across the upstream part to allow the installation of the tramway platform, reinforcing the existing structures to support these new loads with the construction of a new reinforced concrete slab to replace the upstream side deck, and widening the structure with a footbridge for pedestrian and cyclist traffic. All this in a dense urban environment with **no interruption** to Parisian traffic.




FRANCE 2015

Brotonne Bridge

Reinforcement of the bridge piers

 TYPE
CABLE-STAYED
BRIDGE

 USE
ROAD


Inaugurated in 1977, the Brotonne Bridge has a span of over 300 metres, a world record for a cable-stayed structure at the time. But this colossus suffers from the **climate**; as the temperature differences between the inside and outside of its hollow piers can reach up to 15°C which resulted in cracks in both of them. Reinforcement work is aimed at reducing these scars and preventing their formation. The cracks were treated by injection. Peripheral ribs of reinforced concrete were created inside the piers with deferred stitching to the existing walls. Evenly distributed over the entire height of the piers, composite fabric rings have been glued to complement this reinforcement. Some areas had deteriorated and were repaired by patching with special mortars and passivation of the reinforcements. After these ad hoc repairs, a complete **restoration** of the external facings, visible to the public, was carried out. This coating consists of a modified hydraulic binder.




FRANCE 2017

Thouaré-sur-Loire Bridge

Upgrading work on the Grand Pont in Thouaré-sur-Loire

 TYPE
TRUSS BRIDGE

 USE
ROAD

Over the Loire, corrosion had taken its toll on the 400-metre-long Grand Pont de Thouaré, built in the 19th century. To restore the structure and ensure its future, Bouygues Travaux Publics gave it a total upgrade. The original brick vaulted carriageway has been replaced by an **Ultra High-Performance Fibre reinforced concrete slab** resting on new steel bridge components. This material made it possible to design a slab only 9 centimetres thick, resulting in a saving of 1,500 tonnes compared to the use of traditional concrete. As the steel structure had been affected by corrosion in several places, it was reinforced by the replacement of certain structural components. **Anti-corrosion** protection was applied after complete stripping of the framework. New railings and walkways were also installed. The more contemporary blue finishing coat brings the structure right up date for the 21st century.



FRANCE 2018

Sainte-Croix-du-Verdon Bridge

Crack repair and overall restoration of the bridge

 TYPE

BOX GIRDER
BRIDGE

 USE

ROAD


The Sainte-Croix-du-Verdon Bridge has linked the departments of Var and Alpes-de-Haute-Provence since 1972. The quality of the materials at that time, as well as the means of calculation available, did not make it possible to anticipate the phenomena of **concrete creep** and tension losses in the prestressing cables. In order to reinforce the deck structure, eight additional prestressing cables anchored at the abutments were planned over the entire length of the deck. The transverse structure was reinforced by pairs of prestressed bars. The central span was reinforced with strips of carbon fibre fabric distributed around the box girder. Each crack was then treated by a sealing and resin injection process. At the same time, the superstructures were also restored: waterproofing of the road surface, replacement of pavements, pavement joints and guardrails. In addition, **anti-intrusion devices** for chiropterans (bats) and replacement nesting boxes for swifts were installed.




FRANCE 2013-2020

Saint-Nazaire Bridge

Repair and protection of access viaducts

 TYPE

CABLE-STAYED
BRIDGE

 USE

ROAD

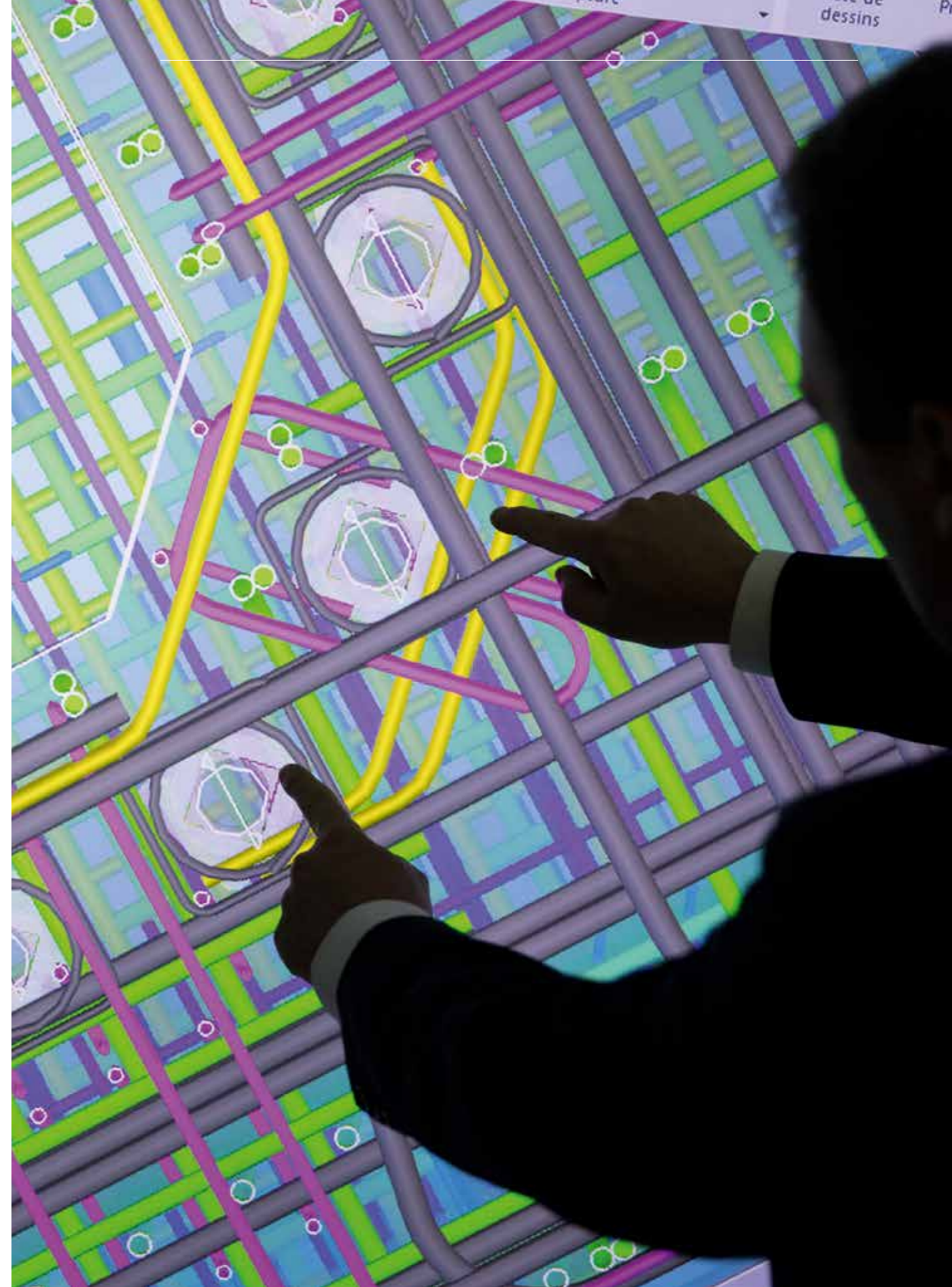
At 3,356 metres in length, this structure consisting of two concrete access viaducts and a cable-stayed steel deck, remains the longest bridge in France. To reinforce the structure of the girders of the south and north viaducts, Bouygues Travaux Publics optimised its methods by designing **floating pontoons** which, hoisted under the spans, served as working platforms. These barges were used to transport equipment, materials and waste. The structural reinforcement of the girders was carried out using an isostatic solution of **additional external prestressing**. The application of strips of carbon fibre composite material locally reinforced the rebar reinforcement. Finished in 2013, the work on the south viaduct was complemented in 2020 with new operations on the north viaduct: installation of a permanent intrados footbridge, repair of the beams, struts and underside of the slabs, application of a coating on 22 spans, protecting the concrete from sea spray and sea air, thus limiting corrosion of the reinforcements.

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, detailed 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?



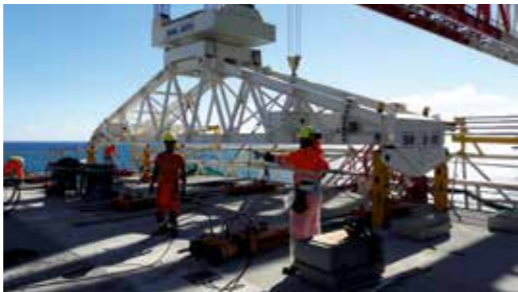
To adapt
to the functional
requirements
of the structures



To reduce
the environmental
footprint of
the works



To meet
complex technical
constraints



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. 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 **laying** land-built prefabricated components in the sea: base sections, pile heads, and mega-voussoirs. A **unique prototype**, this ship has been configured so that it can be operational even in heavy swells.

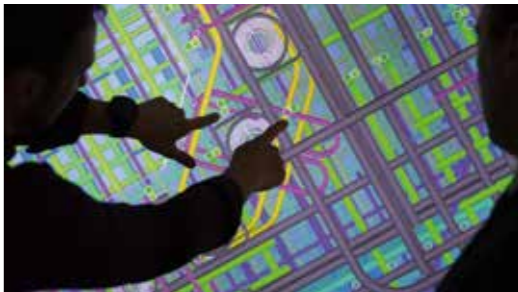
ADELE

Remote-controlled lifting

An automatic hooking and unhooking device enables the lifting of heavy structures without human intervention on the load to be lifted. Thanks to its patented system of transversal lifting rods together with optical sensors, *Adèle* can lift and transport segments from the ground from their prefabrication site to their storage, assembly and installation areas. By replacing traditional foot anchors and avoiding working at height, this innovation reduces the human handling of heavy objects and increases operator **safety**.

180 metres

A record length span with a curve
radius of 513 metres achieved on
the Hong Kong-Zhuhai-Macao Bridge.



CONCRETES

The materials of the future

Research and development of new materials that are more efficient, more durable and more ecological. In association with the Materials Engineering Division, Bouygues Travaux Publics designs fundamental and applied research programmes, in close collaboration with cement manufacturers, on ultra-high-performance fibre-reinforced concrete, recycled concrete and low-carbon concrete. These breakthrough innovations respond to contemporary construction challenges such as improving the **durability** of structures, optimising materials and reducing their **carbon footprint**, as well as the development of the circular economy.

3D REINFORCEMENT

A design-assistance tool

3D modelling of formwork, rebar reinforcements and their assembly, enabling **feasibility** to be validated upstream and **productivity** to be increased. Used for the first time for the design of the reinforcement of the mega segments on piers of the Hong Kong-Zhuhai-Macao Bridge, 3D modelling is now systematically used for all projects in progress. More comprehensive and accurate than 2D plans, 3D modelling makes it possible to create complex structures and facilitates the work of on-site operators.

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 the construction and renovation of bridges and footbridges: operation in restricted spaces, working at height, lifting operations, construction of temporary structures, co-working and risks generated by the continuity of service on related traffic lanes.

Safety is everybody'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



HEALTH AND SAFETY BASICS

A high level of commitment

Protective equipment, traffic flows, risk analysis, ergonomics... 12 standards applied on all Bouygues Construction worksites to ensure the safety of all. At Bouygues Travaux Publics, **specific operating procedures** for activities carried out on engineering structures, such as the use of lifting equipment, analysis of the stability of temporary structures and the definition of traffic and flow plans, complete this common set of standards.

SAFETY CULTURE

A vision shared by all

Technical expertise, a management system and organisational and human factors, the safety culture is based on these 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, an example of its commitment to reinforcing the safety of its staff.

40%

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



SAFETY SURVEYORS

On the look-out on our construction sites

These staff are responsible for checking that safety regulations on every construction site, both in France and abroad, are complied with on a day-to-day basis. Safety Surveyors are authorised to **stop any work** which presents a serious breach of safety regulations or to recommend the exclusion of any person behaving dangerously in order to ensure optimal working conditions throughout the world and to enable a reduction in the number of construction site accidents.

BRIEFING & WARM-UP SESSION

Starting work 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 AND UNDERGROUND STRUCTURES



RIVER & MARITIME WORKS



BRIDGES, VIADUCTS & FOOTBRIDGES



INDUSTRIAL CIVIL ENGINEERING



LINEAR PROJECTS



REFURBISHMENT & REINFORCEMENT



EARTHWORKS



OPEN CAST MINING

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Shared innovation