Le Grand Paris: building the city of the future
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Cover photo:
Bird’s eye view of the Hauts-de-Seine department in the Greater Paris area.

Back cover:
The cutting wheel descends to the bottom of the TBM shaft in Champigny-sur-Marne.
Because part of the builder’s job is to give thought to the city, urban transport and housing, your magazine 360 provides an overview of today’s main social trends, prospects and issues to help us understand them and to guide us in our day-to-day work.
The first phase of the Priminea River’s Bay apartment complex in the Laneuveville-devant-Nancy eco-neighbourhood comprises 32 units. It was handed over in July 2017.
Is more affordable housing possible?

Frédéric Joos
Deputy Managing Director, Adim,
VINCI Construction France

Émilie Saint-Macary
sociologist, urban planner
and Project Manager,
Ville et Habitat

Although the population is increasing, housing construction has still not returned to its 2007 level in metropolitan France. Of even greater concern is the fact that the number of buyers declined 30% over the same period. Clearly, it is steadily becoming more difficult to rent or purchase housing. How did this happen? And above all, what can be done to make housing more accessible again?

Is there a housing crisis?

Émilie Saint-Macary: Yes, there is. The situation today is far less dire than it was in the 1950s, but four million people are currently poorly housed in France and 12 million are at risk. Apart from these alarming situations, which affect a minority, the overwhelming majority of households face high prices and scarce supply of housing in certain areas. The crisis has a number of consequences: low and declining housing market turnover, which is generating a sort of house arrest situation by sharply cutting back on the choice of housing available to households; high prices in city centres, prompting people to move to outer suburbs; and growing inequalities between regions.

Frédéric Joos: In 2017, there were 420,000 starts in France. That is more than in 2016, but still 15% below 2007. During one decade, production has declined by that amount and the number of buyers has dropped 30%.

...
Despite historically low interest rates and lengthy repayment periods, subsidies are declining in areas where the housing shortage is less severe. A majority of people are finding it difficult to rent or buy. It may seem inconsistent.

**How do you see things developing going forward?**

**E. S.-M.:** Housing demand will increase with population growth (by 2040, France will have a population of 70 million) and with the increasing the number of households (later household formation, higher divorce rate and life expectancy). The environmental goals now being factored into construction methods will encourage innovation and a move to reinvent housing that is more suitable (smaller, more modular apartment buildings) and more virtuous (recycling of materials, renovation of buildings, limitation of urban sprawl, etc.) while reducing costs.

**F. J.:** Change can be brought about by adopting policies aimed at building more affordable housing, drawing up standards that take account of economics, and setting up a tax system to help young people purchase property. Technical action can also be taken. VINCI Construction France devised a solution back in 2014 that comprehensively overhauled the residential construction process, the Primmea system. It offers functional housing that is designed with and for its occupants, can be sold at attractive prices and meets the needs of first-time buyers.

**What steps can be taken to foster broad access to homeownership?**

**E. S.-M.:** We need to be careful because selling to households that are too fragile can have serious consequences (dilapidated older condominiums or neighbourhoods, etc.). We need to encourage homeownership and boost market turnover by seeking to produce an affordable stock and secure the homeowner purchase. New systems now emerging should be encouraged, including “baux réels solidaires” (long-term leases in which the building is separate from the land it stands on) as part of “organismes de foncier solidaire” (OFS) community land trusts.

**F. J.:** Remember that construction accounts for 60% of the final cost of a housing unit. We use digital technologies such as BIM(1) to overhaul the construction process from design to execution and maintenance. To deliver new-build housing more rapidly, we have developed an innovative process based on modules with built-in systems

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Since construction accounts for 60% of the final cost, we have overhauled the construction process to offer high-quality housing at attractive prices.**

**Frédéric Joos**
Deputy Managing Director, Adim, VINCI Construction France

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The Primmea project was awarded the “Vitrine Industrie du Futur” label by the Secretary of State for Industry in 2016, which gives it national recognition as an innovative and transformative solution.
such as plumbing and simple, rapid and safe connections. We are able to optimise marketing costs and include them in a comprehensive integrated offering. In a nutshell, we have reduced the number of construction stages and the number of middlemen and created a fully controlled system that strengthens quality and boosts services while limiting the cost.

What role can the construction industry play in reducing market pressure?

E. S.-M.: Industry players have a key role to play in choosing where and how to build. There is a need, for example, to better link housing and employment and to concentrate construction in economically dynamic areas. Among other things, this will reduce commuting time, optimise transport infrastructure, enhance convenience for employees and reduce turnover in companies.

F. J.: The issue must be tackled by all the stakeholders – regional development policy-makers, builders, final customers, and also the developers who award their projects to VINCI Construction France. We, for our part, are open to innovation and look for ways to expand our service offering and reach out to our clients.

Is the involvement of the local population part of the solution?

E. S.-M.: Yes, of course. The re-emergence of cooperative self-build models based on participatory housing programmes involving local authorities, non-profits and individuals shows that people aspire to housing that is more closely tailored to household demand. The inclusion of these schemes in the ALUR Law(3) confirms these production systems as a lasting part of the housing landscape.

F. J.: We take a similar approach. We consult with our future customers ahead of time so as to better meet their needs, and we pay close attention to energy efficiency and comfort (air quality, acoustics, insulation, etc.) A representative panel puts together the various options in our offer via a collaborative platform. But we must do more. For example, we could use digital augmented reality tools to enable customers to more closely monitor construction progress and we could let them inspect their housing unit several months before it is handed over. Measuring satisfaction is also key. It must of course be evaluated when the occupants move in, but also after a period of time – after one year, for example – has elapsed. In this way, we work with customers to create a new homebuyer experience.

Émilie Saint-Macary
Sociologist, urban planner and
Project Manager, Ville et Habitat

ADIM
A comprehensive approach to property development

ADIM, the VINCI Construction France property development structure, is a global operator that supports clients from land search to building operation. As a partner of local authorities and public and private sector companies, the ADIM network of 19 locations throughout France works closely with elected officials and regional planners and uses top specialists to develop smart property projects in consultation with stakeholders.

1. Between 2006 and 2013, the proportion of households having moved into their housing less than four years before declined by 7 points (source: Insee, dossier Île-de-France No. 3, March 2017).
2. Building Information Modeling.
3. Enacted in March 2014, the French law on access to housing and renewed urban planning is designed to regulate property markets, prevent abusive practices and expand innovation and transparency.
5 to 6 exotic species have invaded metropolitan France over the past decade, including the Pallas’s squirrel and the water hyacinth, says France’s National Biodiversity Observatory (OIB). These intruders, often imported, threaten biodiversity and spread more easily when biodiversity is already meagre.

1/3 of all birds have disappeared from the countryside in France over the past 25 years, according to observations by the French National Centre for Scientific Research (CNRS) and the French Natural History Museum.

The urban heat island effect generates a temperature difference that is accentuated at night. Averaging some 2.5°C, it can rise to 10°C between Paris and neighbouring rural areas such as the Rambouillet and Fontainebleau forests.

+ 2.5°C
Building a world attentive to biodiversity

The signature of the Paris Agreements during the COP21 in 2015 amplified the environmental awareness that emerged in the 1990s. The dangers generated by incontrovertible global warming lent new urgency to the need to combat biodiversity loss. As a result, public decision-maker priorities have shifted and goals such as wetland conservation and urban agriculture have come to the fore. Against this backdrop, VINCI Construction is committed to building sustainably and addressing these goals.

Linear transport infrastructure such as highways, railways and inland waterways extends over more than one million kilometres in France and is one of the main causes of landscape fragmentation and isolation of animal populations. Rampant urban sprawl increasingly affects wildlife by encroaching on habitat. Animals and plants are not the only ones to suffer from shrinking natural areas. From highways to car parks and the roofs of buildings, paved surfaces spread in cities, generating a heat island effect and a yearning among city dwellers for green spaces. Surface waterproofing renders the soil incapable of absorbing rainwater and causes increased flooding. How can we solve these problems? Should we build differently? Where will we live in future? How will we travel?

Avoid, Reduce, Offset

In 2008, the white-clawed crayfish, threatened with extinction due to the A65 motorway project in southwest France, became an emblem of the need to protect biodiversity during construction.

Increasingly, infrastructure design has begun to include the Avoid, Reduce, Offset (ARO) sequence. From the start, routes are laid out to avoid harming certain animal and plant species and fragmenting natural and agricultural areas. New algorithms are used to limit and optimise loss of soil supporting abundant species. Reduction of environmental effects is carried out in parallel. When a railway line cuts a watercourse, its impact may be reduced by providing upstream and downstream meanders to support favourable ecosystems for plant and animal species. Numerous structures are built along bridges and roads to connect wildlife habitats. For example, during construction of the Tours-Bordeaux high-speed railway line, 850 structures were built to provide environmental transparency, including 31 crossings for large wildlife that facilitate movement not only for mammals, but also for earthworms and mushrooms. Similarly, 200 ponds serve as fish and bird habitats.

The third step is offsets. A motorway or railway project unavoidably has an impact on its environment. What cannot be
Trends

New green belts in the offing

Located for the most part in Aubervilliers north of Paris, the Condorcet Campus is transforming a 64,500 sq. metre industrial brownfield site into a green lung in the built-up southern part of the Plaine-Saint-Denis area. The approach taken by Adim Paris Île-de-France, a subsidiary of VINCI Construction France, generated a distinctive value-added bid. 64% of the campus will be planted with vegetation to provide users with refreshing green spaces. Biodi(V)strict® was used to assess the landscaping designed by the TER agency and validate biodiversity potential. The variety of habitats designed to foster local animal species was increased 50% and a 600 linear metre network of stormwater ponds* has tripled the permeability of the property.

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* A sort of ditch planted with vegetation that collects water and drains it via an overflow outlet or allows it to evaporate or seep into the soil, thus regenerating groundwater. It is wider and shallower than a conventional ditch.

From ecodesign to positive biodiversity

The presence of nature in the city has become a key factor in the quality of urban life. Some eight out of 10 city dwellers wish to live near a green space. Meanwhile, ecosystems offer an innovative way to design a resilient – sustainable, adaptable and scalable – urban area. In keeping with this growing awareness, VINCI and AgroParisTech researchers forged a
AgroParisTech) is a biodiversity and urban agriculture consulting firm set up in 2017; it uses these tools to help project developers actively participate in conserving and restoring nature in the city. It offers solutions that promote biodiversity and provide services for the city and its inhabitants: refreshing oases of abundant vegetation, rainwater purification through better soil permeability, improved quality of life and social ties in shared planted areas, and even shorter food supply chains thanks to urban agriculture. All solutions are scientifically measured and validated and meet certification and label biodiversity requirements (HQE®, BREEAM®, LEED®, Effinature, BiodiverCity®).

one-of-a-kind partnership 10 years ago. They began by creating the Chair in Ecodesign and then built on the work of PhD candidates to develop innovative methodologies and tools such as Biodi(V)strict® to help optimise decision-making with respect to biodiversity and urban agriculture. “Biodi(V)strict® is a diagnostic and measurement tool that facilitates the inclusion of biodiversity in urban and suburban development and construction projects,” says Urbalia CEO Florence Marin-Poilot. “It is used in the brief or design stage to assess the project’s biodiversity potential and the services provided by nature and support decision-making.” Urbalia (held jointly by VINCI Construction France and AgroParisTech) is a biodiversity and urban agriculture consulting firm set up in 2017; it uses these tools to help project developers actively participate in conserving and restoring nature in the city. It offers solutions that promote biodiversity and provide services for the city and its inhabitants: refreshing oases of abundant vegetation, rainwater purification through better soil permeability, improved quality of life and social ties in shared planted areas, and even shorter food supply chains thanks to urban agriculture. All solutions are scientifically measured and validated and meet certification and label biodiversity requirements (HQE®, BREEAM®, LEED®, Effinature, BiodiverCity®).
Restoring environmental value

Recent development projects systematically accommodate biodiversity, but the residual effects of past projects sometimes require mitigation. For example, dams that reach the end of their operating lives can be removed to restore the ecological continuity of the surrounding countryside; watercourse straightening can be reversed; and embankments can be stabilised through vegetation engineering. Local authorities often include such specifications in calls for tender and Equo Vivo provides the corresponding services. “We assist, oversee and coordinate biodiversity work within the regional entities of VINCI Construction Terrassement,” says Equo Vivo Director Lionel d’Allard. The brand also works on new-build projects to meet demand for restoration of green and blue belts in both rural and urban areas. In both cases, its long-standing expertise supports and guarantees the quality of ecological development. Compliance with the specification is a given; but checking to ensure that nature has returned and ensuring long-term monitoring beyond contractual obligations is an innovation that marks the start of a new era in construction.

2. Land and aquatic ecological continuity defined by the French government and regional and local authorities.

Invasive species on the wane

Development facilitates the spread of invasive plant species to the detriment of native species. The Hermance River near the Swiss border benefited from the experience and expertise of the Equo Vivo teams, who not only restored its morphology and stabilised its banks but also replanted local trees over a large area. The work restored a biological corridor that fosters renewed biodiversity, ensuring effective competition against invasive species such as Fallopia japonica.

Environmental restoration to serve citizens

South of Lyon, major earthworks have been carried out on the Ozon River, originally to address a flooding problem. The municipality of Chaponnay supported an ambitious high-value-added biodiversity project designed to restore the river and its tributary by allowing nature to reclaim agricultural land with a 45 hectare wetland and recreating forest and meadow ponds. The project also included a social and educational objective, creating pedestrian paths to enable people to observe the site as a whole. The project, carried out by VINCI Construction Terrassement, is one of the foundational references of Equo Vivo.
A look at some of the projects that our subsidiaries around the world are designing and building to meet our clients’ increasingly complex requirements and consistently high standards.
ISSA develops local jobs

Equatorial Guinea -
In April, the ISSA (Sogea-Satom Initiatives for Africa) programme awarded funding to Guinean non-profit Futura Generación: Piedad y Letras to build a soap production factory in Etom. About 40 women are involved in the organisation, which offers the village population stable, sustainable employment. They wanted to create a structure to diversify its activities. The cold saponification plant will produce up to 4,800 bars of soap per day and over time will also begin producing shampoo. Unlike imported products, which are expensive and unsuitable, the soap will be adapted to the way of life of local customers. This is the first project in Equatorial Guinea for ISSA, which has been operating in Africa for more than 10 years.

A spectrometric camera that detects radioactivity

Tool - The result of a technology partnership between CEA-Leti, a France-based research institute for electronics and information technologies specialising in nuclear imaging and the teams at NUVIA, a Soletanche Freyssinet entity, NuVISION is a one-of-a-kind portable gamma ray camera. The compact, lightweight device produces a real-time image of radioactive contamination and radioactive sources, including those that are moving. In addition to measuring dose rates and locating and identifying hot spots, including those with low-level radiation, it pinpoints them precisely with a coded mask and provides a 360° view. The revolutionary tool, designed for use by radiation protection experts in nuclear facilities and by work teams at sensitive sites, could prove strategically useful in many civil defence and security related projects.
Work on VINCI’s future headquarters gets under way

Greater Paris area - Construction of the archipel, VINCI’s future head office in Nanterre near Paris, is now officially under way. The first stages will focus on the foundations, with structural works set to take place until the end of 2019. Teams from VINCI Construction France subsidiaries Bateg, Sogea Nord-Ouest, GTM Ouest and Botte Fondations have been busy since the building permit was issued at the end of 2017. The archipel is not the only project being carried out at the site in the Hauts-de-Seine administrative department. Other VINCI entities are working on several projects as part of the western extension of the RER E regional express line*. They are building the future Nanterre-La Folie station, which will be integrated under the VINCI head office, with construction of two new bridges, and working on the tunnel exit of the same line from La Défense.

* Also see Stopover, page 23 ff

First high-speed contract in Germany

Baden-Württemberg - VINCI Construction Terrassement has won a works package as part of the construction of the new high-speed line between Stuttgart and Ulm. The project comprises 5.4 km of earthworks – drainage (900,000 cu. metres), 7.5 km of lateral lines and 8,500 sq. metres of noise barriers. This first contract in Germany is part of one of the country’s largest current projects. It heralds the “Main Line for Europe” high-speed line that will ultimately link Paris and Budapest.

Successful horizontal drilling

Mexico - Entrepose subsidiary HDI Latam completed two 600 metre directional drilling projects at the end of March. Seven such projects were awarded as part of the 42-inch gas pipeline project that will connect southern Texas in the United States with Tuxpan in the Mexican state of Veracruz. The project is set for completion at the end of 2018.

Energy resources

Mexico - Entrepose subsidiary HDI Latam completed two 600 metre directional drilling projects at the end of March. Seven such projects were awarded as part of the 42-inch gas pipeline project that will connect southern Texas in the United States with Tuxpan in the Mexican state of Veracruz. The project is set for completion at the end of 2018.
**Cornerstone laid at the Condorcet Campus**

**Greater Paris area** - Since work on the Condorcet Campus* in Aubervilliers north of Paris got under way at the end of April, it has proceeded at a fast pace, with no fewer than eight cranes already on site. The project, carried out by VINCI Construction France subsidiaries Bateg and Sicra Île-de-France, includes ecological works and the construction of 64,600 sq. metres of HQE® buildings comprising 451 student housing units, the French National Institute of Demographic Studies, research and training spaces, a seminar centre, a residence for researchers, an R&D facility, a university restaurant and various campus amenities.

* See Trends, page 8

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**“Pierre d’Or” for DUO**

**Greater Paris area** - In the 20th edition of the “Pierres d’Or” competition, the DUO towers project in Paris was awarded the Pierre d’Or in the “Programmes” category on 31 January. Designed by architect Jean Nouvel for Ivanhoé Cambridge and built on a general contracting basis by Bateg, a subsidiary of VINCI Construction France, the towers offer some of the most innovative and environmentally friendly office space in Paris, as well as a hotel, a bar with a panoramic view of the capital, an auditorium, shops, gardens and planted terraces.

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**A wider road for improved safety**

**Australia** - VINCI Construction International Network has won the contract to widen the Western Highway in the state of Victoria. The project will improve safety and limit the number of accidents on the section between Buangor and Ararat, just under 200 km northwest of Melbourne. The project involves widening a 12.5 km section to a dual two-lane carriageway and building three bridges and the Hillside Road junction. The AUD 84.8 million project got under way in March 2018 and will take about two years to complete.
**Increased growth outside France**

**Africa** - VINCI Construction International Network continues its expansion in the international airport market with two further projects. It won a substantial contract in Kenya to comprehensively refurbish the runways at the international airport in Mombasa, the country’s second-largest city. With 1.3 million passengers per year, it is the country’s second-largest airport. In addition to restoring the runway lighting system, the project provides for refurbishment of the two runways, 12 taxiways and four aircraft aprons as well as the creation of a rainwater recovery system. There is a specific requirement that the work be carried out at night in order to maintain air traffic during the 24-month project.

**Overseas France** - VINCI Construction International Network also won the contract awarded by the Mayotte airport to build a new, innovative emergency stop system at the end of the runway made up of a safety area composed of recycled glass foam aggregate.

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**A new energy transfer station**

**Morocco** - As part of Kingdom’s renewable energy development and integration plan, VINCI Construction Grands Projets has won the contract to build the Abdelmoumen pumped storage hydroelectric plant. The €284 million hydraulic energy storage project covers execution studies, civil engineering (earthworks for the two reservoirs using VINCI Construction Terrassement expertise, excavation of the underground generation plant, installation of the transfer pipe), supply of transfer equipment and fittings, assembly, testing and commissioning. The project will employ 840 people, including 780 hired locally, for 48 months.
Challenges

Motorway projects

The strength of the construction-concession model

Major motorway projects face a growing number of challenges. They must map out routes across irregular terrain, protect biodiversity from the substantial impact of the infrastructure, decongest dense urban areas while attracting an increasing amount of traffic, and meet day-to-day user needs while accommodating future requirements. A highway construction worksite – in itself a major undertaking – moves people, equipment and activity forward as the project proceeds. Complex projects require top-level solutions at every stage, from contract financing to technical issues, organisation, maintenance and operation. In addition, the project often involves extending or renovating structures subject to heavy daily traffic, in other words ensuring the safety of motorists and construction teams during construction.

New frontiers

To cope with these growing challenges, more and more contracting authorities are working with private-sector companies under public private partnership contracts. VINCI is in a unique position to bid on these projects because it can build on its integrated construction-concession business model to take full advantage of both sectors. The effectiveness of the approach is borne out by its success, particularly outside France. For example, two public private partnerships have given VINCI a foothold in North America. One is the Regina Bypass project in Saskatchewan, where VINCI Construction Terrassement and Eurovia coped with the vast icy Canadian winter to build the 65 km TransCanada Highway bypass in extreme weather conditions, with temperatures sometimes falling below -30°C so that special backfill transport and compaction techniques were needed. When the climate is less extreme, geography can be another challenge. The second public private partnership, the East End Crossing in the United States, finally links Kentucky and Indiana despite the spectacular high water in the Ohio River that had previously formed an insurmountable obstacle. The Lewis and Clark Bridge, a twin-bore tunnel and the region’s first roundabout, built by VINCI Construction Grands Projets and VINCI Construction Terrassement, now connect the two U.S. states.

Large highway projects involve multiple teams from several different companies. Outside France, it is almost always necessary to join forces with local companies, which bring their familiarity with the contracting authority, national regulations and cultural differences to the project. This is particularly important in South America, where VINCI Highways, a subsidiary of VINCI Concessions, has formed an alliance with Colombian construction company Constructora Concreto.
Safety

Safety is a priority on motorway projects, where worksite personnel must be protected and motorists must be warned of danger when traffic is maintained during construction, as was the case during the Bogotá-Girardot motorway widening project in Colombia.

Environment

Some 843 species were identified and 21 kilometres of noise barriers were installed across 12 municipalities during work on the 25 km A9 motorway project (see testimonial, page 21). The environmental impact of highway projects is studied, avoided or offset, and managed over the long term.

Employment

In Greece, two new motorways (Corinth-Patras and Maliakos-Kleidi) employed some 10,000 people at the height of construction activity and about 1,000 jobs were confirmed for operation of the infrastructure; in both cases, job creation helped boost the country’s economic recovery.

Quality

At the request of the concession grantor, the Lewis and Clark Bridge project in the U.S. states of Kentucky and Indiana was built for an exceptionally long 100-year service life. Special concrete and greater quantities of reinforcing steel and coating were therefore used in its construction.
On the Colombian motorway project, we looked beyond our business activities to approach the works from the vantage point of the concession company.”

Bruno Bernet
Executive Vice President, International, VINCI Construction Terrassement
Anticipating risk
In Colombia, VINCI Highways, VINCI Construction Terrassement and VINCI Construction Grands Projets joined forces to build a 65 kilometre third lane and operate a 141 km section of the motorway between Bogotá and Girardot.

“On this project, we looked beyond our usual business activities to approach the works from the vantage point of the concession company, which sees the project in a 30-year timeframe. Every time we made a technical change, we asked ourselves whether it would make the project easier or more expensive to operate,” says Bruno Bernet, Executive Vice President, International, at VINCI Construction Terrassement. After setting up appropriate procedures, VINCI Highways worked with its partner to manage traffic during construction in a country with a high level of road accidents.

The same approach to different business activities
These first successful projects in the Americas illustrate the benefits of the business model. A concession company trusts a construction company if it is familiar with its procedures and operational excellence. “Our common interests are aligned,” says Fadi Selwan, Executive Vice President of VINCI Concessions and Chairman of VINCI Highways. “This enables us to optimise our bids. We stand out from the competition because we are able to spread capital investment over time, improve routes compared to baseline and bring our experience as a motorway operator to the project.” Synergies that have proven effective on major motorway projects may also prove useful in other major projects. Large stadiums, for example, which are now designed to serve as venues for both sports competitions and cultural events, and airports, such as the one in Santiago de Chile managed by VINCI Airports and built by VINCI Construction Grands Projets, also call for early dialogue between the builder and the concessionaire to ensure that construction and later development result in successful operation.

“Maintaining a good relationship with local residents is crucial”

“VINCI Construction’s work on a number of phases of the A9 motorway project in the Montpellier region – one of the most congested arteries in France – took place in an urban or semi-urban environment. Maintaining a good relationship with local residents was crucial, given the dust, the noise and the need to work at night. Local residents make no distinction between VINCI Autoroutes, the A9 concessionaire, and the construction companies that worked on the project. If the company does not conduct an exemplary project, the Group’s reputation will suffer throughout the concession period.”

Salvador Nunez
Operations Director, VINCI Autoroutes
Grand Paris stopover
Stopover

Le Grand Paris

Building the city of the future

The Grand Paris project, the largest development programme in the French capital since Haussmann’s work in the 19th century and currently the largest infrastructure programme in Europe, will change the face of Paris and its surrounding municipalities. Launched in 2010, it kicked off 20 years of construction work, most of which will be carried out underground. In reinventing the city, the worksite of the century faces an unprecedented series of challenges.

Spectacular, tremendous, Pharaonic – superlatives hardly suffice to describe the scale of construction work on the outsized Grand Paris project. The many current and planned projects will shape the contours of a European – even global – metropolitan area and serve as a model for other conurbations around the world.

The leading emblematic project of the urban reconfiguration is the Grand Paris Express (GPE), a high-tech transport network made up of 200 kilometres of automatic lines, 85% of which runs underground, as well as 68 new stations and as many emerging neighbourhoods. By connecting regions and opening up isolated areas, the new-era suburban train will help transform the city and its outlying areas into a denser urban network. The Grand Paris project is also generating substantial urban renewal, economic development and job creation momentum. The choice of Paris as a venue for the 2024 Olympics gives a further boost to the programme by stepping up the construction schedule for the “Olympic” lines. With nearly 300 Grand Paris projects already under way, the Paris area is vaulting into a new era.

The many project challenges

The Paris area rail transport landscape is being restructured to bring the metropolitan region together, with the westward extension of the RER E (Eole project) regional express; the adaptation and upgrade of Lines 4, 11, 12 and 14; and the construction of new Lines 15, 16, 17 and 18. The new network will make it easier to travel from one suburb to another without going through Paris, reinforce connections between airports, business and research centres, universities and regions and significantly cut travel times, while reducing pollution and traffic jams.

As a respected underground works contractor, VINCI Construction is naturally bidding on the calls for tender issued by the GPE programme manager, Société du Grand Paris (SGP). VINCI Construction has brought most of its entities together and organised them in project mode to tackle each project’s many highly challenging issues. One of the most complex is subsoil geology. Intensive underground quarrying in the Paris area during the 19th century left behind caverns and tunnels. Before excavation work can get under way, steps must therefore be taken to ensure the geological stability of the terrain. These include injecting materials into the subsoil and monitoring surface structures to prevent the slightest shift in equilibrium. These operations are being carried out for the most part under buildings, shops, and even railway stations that are continuing to operate. The highly urbanised environment is a constant logistical concern. On teeming worksites where equipment
is being installed, materials are being delivered and spoil removed, workers are busy and vehicle traffic must be managed, all within very restricted areas, the teams must constantly optimise their supply and delivery processes.

**Ramping up operations**
Given the scale of the projects to be carried out simultaneously, human resources are also a considerable focus of attention. VINCI Construction set up a special Grand Paris HR unit tasked, among other things, with calculating human resource requirements. Its director, Macha Koulikov, says that “We need to quantify resources in order to know how many supervisors and workers will be needed. A good overview helps us to organise our employees and...”

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### Key figures

**Area**

- **Number of cities covered**: 131
- **Total surface area covered**: 138 sq. km
  (1.5 times the area of Paris proper)
- **Housing units**: 250,000
  could be built between now and 2040
- **13 million**
  sq. metres of floor area could be built for business activity

**Transport network**

- **Automatic lines**: 200 km
- **New lines**: 4
  (Lines 15, 16, 17 and 18)
- **Line extensions**: 5
  (Lines 4, 11, 12, 14, RER E – Eole)
- **New stations**: 68
- **Daily ridership**: 2 million
calculate how many people to recruit and how many apprenticeships and work integration opportunities to provide. Training courses have been set up to compensate for shortages of specialist profiles and another programme has been designed for people employed in soil works (see page 30).

Beyond preparations for construction, operations are being ramped up in the communities involved. The new neighbourhoods that are expected to emerge around the new stations cover a total surface area of 138 sq. km, i.e. one and a half times the area of Paris proper.

Between now and 2040, some 250,000 housing units and 13 million sq. metres of floor area for local business activities may be built – a staggering amount of construction work, which entails a duty for construction companies to provide social initiatives in the cities involved. The Chantiers & Territoires Solidaires endowment fund, initiated by VINCI Construction France and co-founded by VINCI Construction, VINCI Energies and Eurovia with support from the Fondation d’Entreprise VINCI pour la Cité, supports public interest projects dedicated to creating and maintaining jobs and developing social ties in the vicinity of Group worksites. Following a first call for projects, 11 non-profit organisations operating near the T3C worksite on Line 15 South have already received support from the Fondation d’Entreprise VINCI pour la Cité, supports public interest projects dedicated to creating and maintaining jobs and developing social ties in the vicinity of Group worksites. Following a first call for projects, 11 non-profit organisations operating near the T3C worksite on Line 15 South have already received

Metro systems: acknowledged expertise throughout the world

A few iconic VINCI Construction projects in France and around the world.

**Copenhagen**
Extension of metro Line 4, including construction of a 4.4 km tunnel and 5 stations.

**Doha**
Design-build construction of the dual-tube line and 5 underground stations.

**Hong Kong**
Construction of a 700 metre tunnel for the new Shatin to Central Link (SCL).

**Jakarta**
Installation of a seismic isolation system to reduce seismic load on the Light Rail Transit (LRT) system.

**Cairo**
Boring of the 17 km tunnel for the city’s east-west metro Line 3.

**London**
Construction of the tunnels for the Liverpool Street and Whitechapel stations.
Metro systems: acknowledged expertise throughout the world

Lyon
Extension of metro Line B to open up the southwestern part of the city.

Marseille
Boring of a 1,900 metre tunnel and construction of the Line 1 terminus.

Rennes
Boring of a deep 8.5 km tunnel for the second automatic metro line.

Singapore
Construction of 26,000 sq. metres of diaphragm walls using a compact HC05 Hydrofraise® machine.

Rennes
Boring of a deep 8.5 km tunnel for the second automatic metro line.

funding. The Group is also working to meet two SGP requirements: awarding contracts with a value equivalent to 20% of its revenue to regional SMEs, and earmarking 5% of the hours worked for the long-term unemployed. On this last point, VINCI Construction has in fact set its sights higher and will work with its VIE (VINCI Insertion Emploi) work integration structure to achieve 7 to 10%. “We help Group companies and their subcontractors in order to ensure that the work integration objective is not perceived as an obligation but rather as an added value,” says its director, Arnaud Habert. VIE is managing 350,000 integration hours on the e-déf Eole-La Défense project. On that project, the team took another initiative to address a different social challenge: several employees decided to support a non-profit that helps the homeless in the La Défense district by organising a monthly collection of basic necessities to cover specific needs.

Limiting impact
In 2016, VINCI Construction and Spie batignolles won an iconic works package that heralds the transformation of the Greater Paris area. It is part of the Eole project (the RER regional express extension to the west of Paris) and covers construction of the CNIT-La Défense station and its adjacent tunnels for SNCF Réseau. An operational excellence programme based on lean management was set up on the worksite to encourage continuous improvement, waste reduction and collective intelligence. In other words, as the project’s HSQE and Operational Excellence Director Ala Samba Timera puts it, “This programme is aimed at controlling all processes to achieve overall performance.” Another operation carried out in the area around the Nanterre-La Folie station is the earthworks, engineering structures and communication restoration works package awarded to a joint venture led by Chantiers Modernes Construction (VINCI Construction France). Since then, another VINCI Construction joint venture, in association with Spie batignolles, has won several GPE (Grand Paris Express) works packages: the extension of Lines 4, 12 and 14 South, an 8 km tunnel and the Noisy-Champs forward station and station on Line 15 South. Meanwhile, Soletanche Bachy (a subsidiary of VINCI Construction) won three contiguous works packages on Line 15 South together with Bouygues Construction within the Horizon joint venture, as well as in conjunction with Léon Grosse. Lastly, Chantiers Modernes Construction. • • •

Worksite cultural events are held to bring together the regional stakeholders. When the first tunnel boring machine was launched on Line 15 South, residents of Champigny-sur-Marne were invited to watch the cutting wheel descend into the shaft.

Construction of an 8.2 km tunnel, eight shafts and five new stations between Fort d’Issy-Ves clos-Clamart and Villejuif Louis-Aragon to connect the cities in the southern Paris suburbs with each other.
Stopover

and Soletanche Bachy are currently working on the Line 11 extension. These multiple worksites are causing inconvenience and disruption. Every day nearly 2,000 tonnes of earth are excavated, generating noise, vibrations and dust emissions. Special attention is therefore paid to local residents, who are the most highly affected. Each worksite has a dedicated staff member to interact with them, and measures are systematically taken to assist them. For example, on the e-déf Eole-La Défense project, an acoustic hangar was built above the Gambetta shaft to reduce disruption for the residents of Courbevoie with whom the teams will be cohabiting for five years.

**Tools and methods commensurate with the challenges**

GPE construction work will generate an estimated 43 million tonnes of spoil—a figure suggestive of the challenges of removing it, especially since some of it is contaminated. VINCI Construction is carrying out surveys to classify the materials to be removed according to their toxicity level using in-house expertise. Carasol determines the nature of spoil twice as fast as conventional methods, Extract Ecoteries defines a removal strategy for each type— inert, hazardous or non-hazardous—and Remea provides site remediation and polluted effluent treatment expertise. In addition to protecting the environment, projects focus systematically on safety of both people and property. VINCI Construction uses innovation to enhance safety. One of its inventions, the gripper Hydrofraise®, is used to control geotechnical risk by supporting the ground during excavation to ensure safety and save time. CAP 3D offers the same advantages with its real-time TBM control system. Safety of personnel is a core priority and a focus at all times, from initial training to the WISE wireless geolocation and telephony system, which protects workers in tunnels in the event of a fire (see *Innovation, page 38*) and ongoing refresher training. SGP estimates that the new-era suburban train project will generate additional growth in the region amounting to between €100 and 200 billion and will create more than 115,000 indirect jobs.

**Imagining urban well-being**

In cultural terms, the effects of the future infrastructure are already being felt. A GPE endowment fund set up in 2017, which VINCI Construction joined as a “major partner” in the group of sponsors, is implementing a series of projects supported by private funding. Its director, Pierre-Emmanuel Becherand, explains its purpose: “We thought it important to use culture to help boost social ownership of a project that will take such a long time to complete.” Emblematic activities include original artwork in each of the new stations and KM – kilometre – worksite celebrations. The celebration held for the launch of the first tunnel boring machine on Line 15 South drew more than 4,000 participants. The Grand Paris project has boosted the property market, already buoyed by low interest rates, greater economic optimism and local authority support. Patrick Supiot, Deputy Director, Business Property and Development at VINCI Immobilier, explains their goals: “Local authorities, keenly aware of their
Given the scale of the projects, human resource requirements are huge. VINCI Construction has therefore set up a Grand Paris HR unit to coordinate in-house worker assignment and plan the necessary recruitments.

The western extension of the RER E (Eole) line is designed to strengthen connections between the eastern and western parts of the Greater Paris area. Existing RER Line E will be extended westwards by 55 km (including 8 km running in a tunnel) from the Haussmann Saint-Lazare station to the Mantes-la-Jolie station.

350,000 cu. metres of excavated materials will be removed from La Défense, France's largest business district with 200,000 users per day and 8 million tourists per year.

The Grand Paris project offers a one-of-a-kind opportunity to take a new look at the urban area, disrupt habits and rethink the balance between built and green spaces. VINCI Construction has taken on these issues in an endeavour to use technology to serve urban biodiversity.

constituents’ aspirations for new patterns of urban life and a more citizen-friendly urban environment, are looking for more mixed-use development.” VINCI Immobilier teams respond by working in synergy with urban planners, architects, start-ups and sociologists to foster the emergence of innovative approaches to the design of neighbourhoods, public facilities and buildings that will have a long-term impact on the future Grand Paris urban area. This means pushing the envelope, disrupting habits and rethinking the balance between built structures and green spaces – all topics that VINCI Construction has embraced in its work to ensure that technology serves urban biodiversity (see Trends, page 8). These topics are also the remit of the Chair in Eco-design of Buildings and Infrastructure, developed in partnership with three ParisTech schools, and of Urbalia, a start-up held jointly by VINCI Construction France and AgroParisTech.
Expert opinion

Françoise Sœur,
Training and Development Manager,
Grand Paris HR unit

1998 Works foreman

2012 Skill Up training programme initiative for local personnel on VINCI Construction Grands Projets worksites.

2016 In association with the VINCI Academy, develops the SPOC (Small Private Online Course) on temporary structures. In parallel, designs training courses for Grand Paris projects.

2017 Training Engineering Manager within the Grand Paris HR unit.

“We are creating a ‘city below the city’ generation”

“We have developed a dedicated training course for work on The Grand Paris project. It is designed and conducted by in-house experts for VINCI employees involved in the works and employees of our partner Spie batignolles. Called the ‘City below the City’, it is designed to instill a ground works culture and more specifically targets works engineers, methods engineers, contract managers, design-works coordinators, etc. Following a brief e-learning introduction, the nine-day training course is conducted in the classroom and spread over four modules. The first module on special works describes the different types of special foundations and the criteria used to determine construction methods. The second focuses on underground works and highlights conventional methods using a tunnel boring machine. The third covers soil properties and the associated contingencies and precautions. The contract management module concludes the training. The course is primarily concentrated on risk management under public procurement contracts and includes a presentation by a lawyer, who describes the case law. The idea is to learn how to avoid litigation by taking early action.”
We submitted a proposal in response to a national call for industrial sustainability demonstrator projects. Our proposal was called ‘Rêve de Scènes Urbaines’ (dream of urban scenes) and located in the Plaine Commune* area. The system constitutes a new way for regional authorities, businesses, academics and non-profit groups to work together to devise innovative urban solutions that incorporate all aspects of the sustainable city. Rêve de Scènes Urbaines is the name of both the demonstrator and the non-profit supporting the project, which VINCI chairs. Every six months, we submit a suggestion box with 150 collective proposals for innovations and experiments in rebuilding the city over the city. Plaine Commune selects about 20 of them and conducts feasibility studies. The first two suggestion boxes covered the area earmarked for the Olympic Village. About 40 projects are being designed or developed. The participating companies are meanwhile thinking about ways to showcase the work done via a publication to be issued in the last quarter of 2018.

* Plaine Commune covers nine cities in the Seine-Saint-Denis department (Aubervilliers, Épinay-sur-Seine, l’Île-Saint-Denis, La Courneuve, Pierrefitte-sur-Seine, Saint-Denis, Saint-Ouen, Stains and Villetaneuse) and has a combined population of 430,000.

“A new way for city stakeholders and public authorities to work together”

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Massive grout injections

A dense group of underground quarries concentrated in a very small footprint: this is the challenge to be tackled by a joint venture led by VINCI Construction Grands Projets. Dodin Campon Bernard, VINCI Construction France and Botte Fondations have been working with Spie batignolles on this works package – the largest on Line 15 of the Grand Paris Express – since February 2017.

Their task consists in building an 8 km tunnel, five new stations and eight shafts to connect the underground Fort d’Issy-Vanves-Clamart station with the future Villejuif Louis-Aragon station. Prior to the start of the project, the teams must restore the geological stability of the site. As Philippe Athuyt, Director of the Overseas France sector at VINCI Construction Grands Projets, explains, “To rule out the risk of damage, we are going to consolidate more than 80 different areas by injecting materials, perform detailed analyses and instrument the above-ground buildings to ensure permanent monitoring.”

Limiting disruption for buildings and residents is one of the joint venture’s main concerns. For this reason, an innovative technology will be used to build the four shafts – a VSM (Vertical Shaft Sinking Machine) made by Herrenknecht. It operates like a vertical tunnel boring machine to perform two operations simultaneously: boring the shaft and installing the segments that will form its walls. This saves time and above all takes up less room, a particularly welcome advantage at the restricted site. In addition, it reduces noise and ensures greater safety, because no personnel are required to work within the structure.

3.3 tonnes of spoil.

8.2 km tunnel to be built.

85 metre depth, made possible by the use of VSM technology.
The Eole project – the RER extension to the west of Paris – comprises some 20 worksites, including the underground La Défense station, which involves an exceptional technical challenge: underpinning the entire CNIT building complex comprising some 75,000 tonnes of loads to be transferred to the new station foundations. The teams working within the joint venture led by VINCI Construction France are building what amounts to an underground cathedral (110 metres long, 33 metres wide and 15 metres high in the centre) under the CNIT, while the shops, car parks and hotel remain in operation. To limit disruption during the works, an acoustic shield was installed under the CNIT. The goal is to achieve zero noise and zero vibrations. Up to 700 people are expected to be involved in the works, which got under way in the summer of 2016 and also include construction of adjacent tunnels.

At the exit from the future CNIT station, work has been proceeding apace on another project, the TOARC 5400*. Management of excavated materials differentiated by level of contamination – the culmination of the operation – has been entrusted to a joint venture led by Chantiers Modernes Construction, a subsidiary of VINCI Construction France. This major undertaking involves work by VINCI Construction Terrassement to excavate 400,000 cu. metres of materials, of which 240,000 cu. metres must be removed. Site material recycling techniques foster re-use. The work is subject to stringent phasing involving simultaneous excavation, backfilling, consolidation and supply operations.

* Earthworks, engineering structures and communication restoration.

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**e-déf Eole-La Défense project**

**An underground cathedral in La Défense**

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3.5 million hours worked on the e-déf Eole-La Défense project.

400,000 tonnes of aggregate supplied by Eurovia for the Eole project concrete.

6 intermediate deadlines and 12 milestones.
Line 15 South, the Noisy Champs forward station and station

The bold architecture of a strategic station

As one of the nine “emblematic” GPE stations, Noisy-Champs was designed to impress with its helical dome imagined by architect Jean-Marie Duthilleul*. The superstructure made up of two intertwined helices rises 25 metres above the existing RER A station. It will consist of a 1,500 tonne metal frame comprising 12 posts, main beams supporting the entire roof, a zinc-covered wooden structure and vertical glass facades. The contract won by VINCI Construction subsidiaries VINCI Construction France (lead), VINCI Construction Grands Projets, Dodin Campenon Bernard and Botte Fondations in association with Spie batignolles includes a forward station, the station itself (which will connect the RER Line A with Lines 11, 15 and 16) and the metal frame, glass facades and a variety of pedestrian walkways.

The station is the Grand Paris Express system’s only envelope structure. It will be 150 metres long, 70 metres wide and 30 metres deep with three levels. There is one major construction constraint: the existing station will remain in operation throughout the works, i.e. until 2022.

Located at the intersection of several lines, the Noisy-Champs station project requires very precise phasing. The work will take place simultaneously in several areas (tunnels, stations and hangars) on a land take that is about 1 km long and 100 metres wide. In the first half of 2018, the project reached a major milestone when the 118 piles (40 metres deep and 1,200 millimetres in diameter) of the forward station structure were completed. The teams completed the 500 linear metres of 35 metre deep diaphragm walls in July and handed the project over to the earthworks and civil engineering teams.

* A railway sector specialist, Jean-Marie Duthilleul notably initiated the Paris-Saint-Lazare and Paris-Lyon station restructuring projects.

1,500 tonnes of framing for the dome.
12,000 tonnes of rebar (foundations and civil engineering), i.e. twice the weight of the Eiffel Tower.
120,000 cubic metres of concrete (diaphragm walls, piling and civil engineering).
Hardly had the notification to proceed been issued on 22 February than the joint venture led by VINCI Construction in association with Spie batignolles placed the order for the first tunnel boring machine. At the same time, work got under way on worksite installations and preparatory geotechnical surveys and spoil analysis were launched.

Four months later, the focus shifted to quarry treatment, followed in July by the construction of the diaphragm walls for the launch shaft. The brisk pace was needed to meet a very tight schedule, says Guillaume Thouvenin, Project Director at Dodin Campenon Bernard. “We are boring 4.6 km of tunnels between the future Maison Blanche - Paris 13 station and the Jean Prouvé TBM launch shaft within a very short timeframe in order to hand over to the tracklaying team on schedule.”

On this works package, for which the RATP is serving as client representative for SGP, the joint venture is in charge of the Line 14 South extension that will connect the Olympiades station with Paris-Orly Airport, a priority project in the runup to the 2024 Olympic Games in Paris. The contract also includes construction of five ventilation and emergency shafts as well as the new Kremlin-Bicêtre Hôpital station. The latter, an important node, will be built inside the hospital, which will continue to operate during the works. Very careful attention is paid to vibrations and dust in the demolition phases. An additional complication is the passage above Line 15 at the Villejuif Institut Gustave-Roussy station. “This is one of the key parts of the project,” says Guillaume Thouvenin. “It calls for flawless coordination between both line projects. We have already assigned a person to plan work on the interface.”

3 tunnel boring machines working simultaneously, starting in the first quarter of 2019.

260,000 residents of Paris and the Val-de-Marne and Essonne administrative departments will use the Line 14 extension.

15,364 square metre surface area of the Institut-Gustave-Roussy station.
The Line 12 extension project in northwestern Paris continues apace. Following a first phase focused on building a tunnel, the Front Populaire station (which has already opened), a launch shaft and four access shafts, structural work is now starting on the Mairie d’Aubervilliers and Aimé Césaire stations. The first, which will interconnect with the Grand Paris network, will be 220 metres long and 26 metres deep; the second, with a length of 83 metres, will reach a depth of 29 metres. A joint venture made up of Chantiers Modernes Construction, Dodin Campenon Bernard and Botte Fondations is building it for the RATP. The stations will be built within the tunnel already completed, protected from groundwater ingress by diaphragm walls. The difficulty arises at the tympanum* between the station wall and the tunnel, where the terrain (made up primarily of Beauchamp sands) exerts strong water pressure. To prevent water ingress and consolidate the terrain, the joint venture is using a technique – ground freezing – that is not widespread in France, although not unprecedented: during construction of Line 4 of the Paris metro in 1899, engineers froze the soil under the Seine by injecting a brine solution cooled to -24°C.

On the Line 12 project, the technique has evolved to some extent (see 360, issue No. 48). 1,700 metre long freezing pipes are installed, through which brine flows at a temperature of -35°C. For the Mairie d’Aubervilliers station, a mixed solution that can use either brine or liquid nitrogen cooled to -196°C was selected.

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1,700 metre freezing pipes at station ends.

85,000 cubic metres of concrete pumped from the site’s two mixing units (diaphragm walls, slabs, beams, raft).

30,000 square metres of diaphragm walls with thicknesses of 1,000 and 1,200 millimetres at the Mairie d’Aubervilliers and Aimé Césaire stations.

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* Tympanum vertical wall at a sharp cross-section change within a tunnel.
What matters is not only what is accomplished but how it is accomplished. We routinely use innovative methods and customised technological solutions (tools, materials, techniques, processes, etc.) to boost the economic, social and environmental performance of our projects.
Innovation

Reinventing the city, underground and above ground

Intelligence and digitalisation are central processes used to build the city of the future. They start with the design of the “city below the city”, a prerequisite for the construction of the stations and infrastructure that will serve the 68 new Grand Paris neighbourhoods. Safe construction, smart buildings and energy savings are just some of the fields in which VINCI Construction is devising specific solutions that herald a good life within a sustainable, comfortable metropolitan area.

State-of-the-art methods and construction modes are used on all worksites. This is a crucial prerequisite for meeting the challenges of a project on an unprecedented scale. Innovation is a focus at all levels – both below the city and above it.

Combining efficiency and safety below the city
The Paris subsoil is often described as a “Swiss cheese” because of the abandoned quarries, tunnels and utilities that run through it. Care must constantly be taken to ensure safety. The question of how to work efficiently while ensuring the safety of workers and the stability of surface buildings is a conundrum that is prompting a renewed effort to think up and implement suitable solutions. One is the gripper Hydrofraise® rig designed by VINCI Construction subsidiary Soletanche Bachy, which is used to build special foundations. It is currently in use on the Paris metro Line 14 extension and Line 15 construction projects, where it is reinventing the diaphragm wall process with tooling that can cut through very hard rock thanks to its more than 120 tonne thrust to build walls that are 70 metres deep and between 1.2 and 1.8 metres thick.

The CAP guidance software developed by another VINCI Construction subsidiary, Dodin Campenon Bernard, offers similar advantages. In combination with a real-time navigation system, it allows very precise control of tunnel boring machines. In 2017, CAP introduced a new module called CAP 3D that provides a 3D representation of the entire project (built structures, geology, subsidence values, tunnel and station interior, etc.). The data collected improves excavation performance and guides the teams through difficult areas. Workers can also use WISE, a system designed for confined spaces. The wireless network architecture ensures communication and location even in the event of a fire. It is currently used on the CNIT project and will soon be widely deployed in our underground operations, especially the Grand Paris works packages.
Fostering the emergence of the Smart Green City

In above-ground operations, as in underground works, safety and sustainable construction criteria apply. “Green” cities that protect biodiversity, conserve ecosystems and return spaces to nature while adopting energy-saving systems are the way of the future (see Trends, page 8). To cut the impact of its activities to a minimum, VINCI Construction is developing BIPV (Building Integrated Photovoltaics) technologies. The most recent result of this quest, Horizon Energy, is a curtain wall made up of photovoltaic glazing. The product, developed in partnership with French solar innovation company Sunpartner Technologies, is used to build positive-energy buildings and joins another energy-autonomous product, the Horizon window. The Internet-connected window fitted with electrochromic glass shifts from transparency to opacity without blinds or electrical connection. Building interiors are also a focus of innovation. A Heating, Ventilation and Air-Conditioning (HVAC) system embedded in floors, the Greenfloor ventilated slab devised by VINCI Energies, consumes little energy while maximising thermal comfort. All these advanced systems are part of the move to smart buildings in which BMS/BAS* systems will use data to manage operations.


Listening technologies

Underground works in dense urban environments may damage above-ground land or nearby built structures. SIXENSE, a subsidiary of Soletanche Freyssinet, performs detailed monitoring to prevent this. Examples are the Line 15 South construction and Line 14 South and RER E western extension (Eole) projects. The Group has developed high-quality technologies to monitor soil and structure movement in three dimensions and in real time. Its Geoscope platform controls sensors linked to alarm systems. Any settlement or deformation is rapidly detected, making it possible to take immediate countervailing action.
Facts and figures

1,820

metres

of large-diameter pipes were laid under the Axios River in Greece in a record “one shot” trenchless directed drilling operation.

In Greece, HDI (Entrepose Group) managed to install a 1.20 metre diameter, 1,820 metre long pipe in a single section without intermediate shaft on the Trans Adriatic Pipeline (TAP) project. The TAP gas pipeline is the European section of a large-scale fossil fuel infrastructure project that starts in Azerbaijan, crosses the Anatolian plain, Greece, Albania and the Adriatic Sea and ends at the Italian coast to bring natural gas from the Shah Deniz II field in Azerbaijan. The pipeline is one of the European Commission’s projects of common interest (PCIs). It will help usher in the energy transition by limiting the use of the fossil fuels that generate the greatest amount of pollution (coal and oil). The goal is to reduce Europe’s energy dependence on Russia. The large-scale project includes directional drilling across 13 watercourses, which was entrusted to the specialist HDI company. The trenchless pipe laying technique is particularly well suited to underwater crossings (rivers, estuaries, inlets, etc.). Following an extensive – and in this region highly complex – geophysical analysis of the terrain, an ideal route was mapped out. Directional drilling started on one bank and arrived at the other. It took place in two phases: first a pilot operation of small diameter, followed by several reaming operations to progressively achieve the target diameter and lastly insertion of the pipe by drill rod. The teams that achieved this feat can be proud of their work on this project.
Yamal, a look back at an exceptional project

The Yamal LNG project was inaugurated by Russian President Vladimir Putin on 8 December 2017, nearly a year ahead of schedule, as the first shipment was loaded onto the Christophe de Margerie supertanker. At the Siberian site, located 400 kilometres from the North Pole, synergies between the 1,400 men and women of the Entrepose Contracting - VINCI Construction Grands Projets joint venture were fully operational. The gigantic project included engineering, equipment supply, provisioning, construction and commissioning of four total integrity cryogenic tanks with a unit capacity of 160,000 cu. metres. Each tank consists of an internal tank made of 9% nickel steel alloy fitted into a prestressed concrete external tank. Entrepose Industries manufactured the crucially important 112 roof segments - each 40 metres long - in Dunkirk and transported them to the site by sea. The Yamal project ("Yamal" means "edge of the world" in the local Nenets language) is an impressive human and technical feat, carried out at a fast pace despite temperatures that occasionally fell to -40°C, logistical difficulties and the complexity of building foundations in frozen ground. Its success bears witness to the Group’s ability to coordinate its entities and enlist the full range of its business activities to carry out exceptional projects.

01 Welding in extreme conditions. Employees successfully coped with extreme conditions, including temperatures that could fall by several tens of degrees to -40°C within a few hours.
640,000 cu. metres of gas at the edge of the world. Delivered one year ahead of time, the four 160,000 cu. metre cryogenic tanks stand above the Arctic vastness. The pipe racks – metal structures to which the pipes that operate the tanks are attached – were prefabricated nearly 3,000 kilometres away.
03 Preventing thaw. To cope with the complexity of building foundations in permafrost, VINCI Construction Grands Projets and Entrepose designed an ingenious solution that halves the number of piles (950 per tank). Thermal stabilisers were placed between the piles to maintain the permafrost temperature at below -5°C for a period of 50 years.
04 **Continuous concrete pour.** 17,500 cu. metres of concrete were poured to form the exterior envelope of each tank. The operation was executed using sliding formwork and continuous 24/7 concrete pour. With this process, it took just over 20 days to build the 40 metre walls. In this extreme environment, major concrete pours were avoided during the coldest periods.

05 **A suspended worksite.** The installation of the 112 roof sections, each 40 metres long, was difficult. The segments were manufactured by Entrepose Industries at its Dunkirk site and shipped by sea to the port of Sabetta, a few miles from the Siberian worksite.
No one believed in Eugène Freyssinet’s prestressed concrete technique when he patented the novel solution in 1928. But he persevered, and fate lent him a helping hand when he crossed paths with Edme Campenon, a talented entrepreneur with keen business acumen who enabled him to develop and implement his inventions. Their work together produced results from the start. They began by preventing the maritime terminal in Le Havre from sinking into the silt by using prestressing to consolidate its foundations. They then set up the STUP (Société technique pour l’utilisation de la précontrainte) prestressing company (which changed its name to Freyssinet in 1976) to provide unrivalled civil engineering expertise. The founders’ innovative spirit was perpetuated over the decades that followed, during which hundreds of patents were filed for revolutionary inventions that propelled the company into its position as world leader in prestressing, cable-stayed structures, structural equipment and structural repair, reinforcement and maintenance. Freyssinet participated in iconic projects around the world, including the Normandy Bridge, the Millau Viaduct and the Grande Arche in La Défense in France; the Telekom Tower in Kuala Lumpur, Malaysia; the Vasco da Gama Bridge in Lisbon, Portugal; the Leonard P. Zakim Bunker Hill Memorial Bridge, one of the world’s widest, over the Charles River in Boston, Massachusetts in the United States; and the Hong Kong and Singapore airports. In addition to designing exceptional structures, those who followed in the footsteps of Eugène Freyssinet and Edme Campenon became specialists in exceptional projects – such as repairing the Channel Tunnel in 60 days and raising the Ekofisk offshore platforms in the North Sea – that demonstrate the ongoing vitality of the company’s original visionary approach, 75 years on.
The cutting wheel descends to the bottom of the TBM shaft in Champigny-sur-Marne.