Around the World

7 REINFORCED EARTH® WALLS FOR THE NEW ACCESS ROAD OF THE TOWN OF IQUIQUE

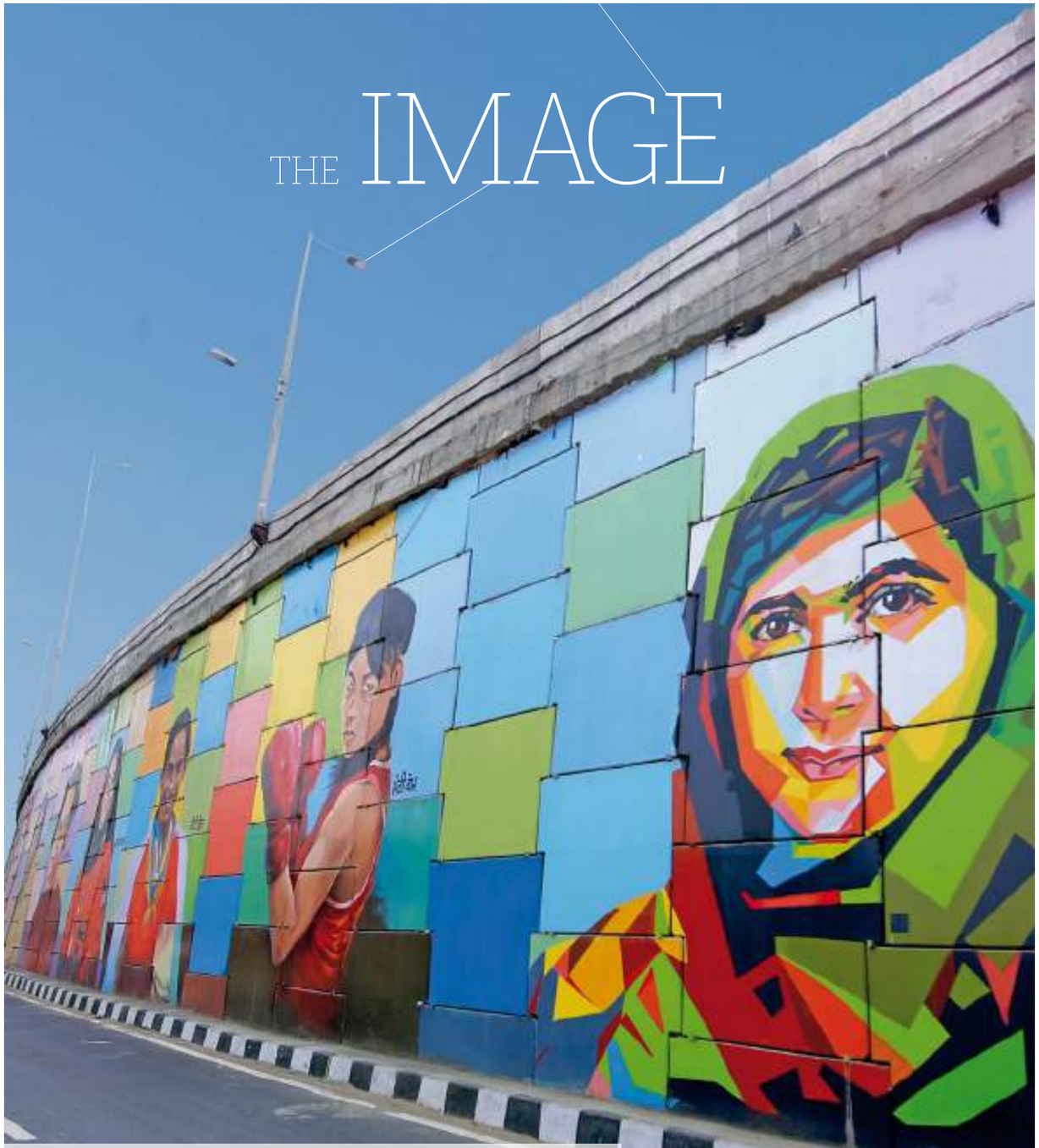
P. 10 CHILE

2nd semester 2018 — N° 231

TERRE ARMÉE Magazine

TERRE ARMEE

THE IMAGE



INDIA

A Reinforced Earth® wall decorated with portraits of inspiring women

In 2018, a Reinforced Earth® wall located on a road bridge in the city of Barnala was chosen as the canvas for a campaign to promote girls' education. Created as part of the government's scheme, the mural illustrates the fundamental importance of education through color portraits of 6 women. They include Malala Yousafzai, the Pakistani activist who won the 2014 Nobel Peace Prize at the young age of 17 for her advocacy of female education. The wall was built in 2017 as part of the roadwork launched in order to improve the flow traffic in the agglomeration. Reinforced Earth India was in charge of designing and providing 23,987 m² of retaining walls using GeoMega® technology.

The word

Terre Armée **well prepared** for the fast-growing railroad market!

VINCENT OUDIN,
CHIEF EXECUTIVE OFFICER

Terre Armée has made its notoriety and reputation on the Reinforced Earth® technology, that has shaped many infrastructures all over the world. The need for transportation infrastructures and land development has mainly been the consequence of urbanization. We now see more and more a need for connecting cities not only by air and roads but also by train, opening a huge market for railway infrastructures in the world. On this fast-developing market, the Reinforced Earth® technology should play a key role on any type of railroad infrastructures: metro, regional railways as well as high-speed railways, as this was the case in the French 350 km high-speed railway between Tours and Bordeaux where MSE walls have been extensively used.

Very early on, Reinforced Earth® demonstrated its full potential in the railway sector for track and track supporting structures. The technique has many advantages including high resistance to static loads, vibrations and earthquakes. It uses materials with outstanding durability. It can be easily adapted to geotechnical and architectural specifications. Reinforced Earth® structures can be built within a short amount of time, require a small land take and have a low environmental footprint.

TechSpan® arches, for their part, are used to build railway tunnels under backfill and cut-and-cover structures. We provide solutions for all types of railway lines, including high-speed, regional transport, light rail and tram-train lines.

I'm also thrilled to see that though historically known for its Reinforced Earth® technology, our company can showcase more and more examples of diversification. The Stampede dam project (pp12-13) is a flagship project in the dam raising activity and will help **PROTECT** surrounding areas against flooding. We can also see more and more diversification in river and coastal protection.

Enjoy the reading and get in touch with us soon!

Contents

Terre Armée Magazine provides a biannual overview of our projects worldwide. The magazine complements our www.terre-armee.com website, which presents more news and information about our business activities.

Terre Armée Magazine, Terre Armée's twice-yearly magazine • **Communication Department:** 280 avenue Napoléon Bonaparte, 92500 Rueil-Malmaison, France **Editorial manager:** Guillaume Billaroch • **Editors in Chief:** Agathe de Constantin • **Contributors to this issue:** Thomas Colombain, Juliette Dumoulin, Karine Vercher, Marie Brunel, Nandini Rath, Jason Zwickl, Nathalie Marcelot, Alain Tigoulet • **Design:** • **Production:** • **Printing:** Frazier **Translation:** Telelingua • **ISSN:** en cours • **Photocredits:** Soletanche Freyssinet Photo Library, Laurent Chartier, Wilhelm Strydom, Leszek Halas, Cyrille Dupont, NW Construction, INC, Ben Seelt, Gobernación de Vargas, Armaan Klickography Studio, Czar, VINCI Photo Library • **Contact:** mag@sf-group.com

The figure

63,000

Number of TerraSquare m²
Reinforced Earth USA will provide for its 2017 largest contract agreement: L95/L295 North Interchange reconfiguration in Florida. The project will be completed in 2020.

The contract

Senegal: Terre Armée has started work in Dakar for the Regional Express Train that will link the city center with the new Blaise Diagne International Airport (AIBD) from 2019.

The company is in charge of the surveys, design, supply and installation of the formwork for 12 Reinforced Earth® access ramps. In total, 17,000 m² of access ramps will be installed, all made up of 3 x 1.5-meter rectangular TerraPlus® panels and GeoStrap®5 reinforcements.

Focus

Denver, USA

Reinforced Earth USA has a new factory! Located in Denver, Colorado, it is entirely dedicated to the production of form liners, tools that are used to leave an aesthetic imprint on facing panels. The Denver factory was built and opened in 2018 in response to high demand, and joins the US subsidiaries' other four factories.

The event

International Geosynthetics Society

12th International Conference on Geosynthetics

From February 10th to February 13th 2019, Terre Armée will take part in the Houston IGS Trade show. More than 1,300 geotechnical practitioners, designers, regulators, contractors, and installers will gather to learn the latest research, materials, applications and case studies in the fields of geosynthetics.

The phrase

"Terre Armée came up with a tailored solution, costs project and price quote in only 24 hours"

ALEXANDRE HENAULT, IN CHARGE OF THE GOURETTE ROAD REBUILDING PROJECT

In June 2018, Terre Armée was called in emergency following the collapse of a road forming part of the route of the tour de France. Terre Armée teams realized in record time the design of a 250 m² Reinforced Earth® retaining wall and provided its constituent elements (strips and panels), thus allowing the rehabilitation of the road before the passage of the cyclists on July 27th.

Watch the video on our Youtube page

The next big thing

A new Reinforced Earth corporate brochure is available! The 40-page brochure showcases our 3 business lines - Retain, Cross, Protect - the techniques and the applications, as well as a number of our project references. Some of the pages include QR codes linking the reader to other contents (web, video).

Download our brochure online

The technology

TechRevetment, a solution for protecting embankments against erosion

PROTECT

• The Challenges

Protect embankments (dry or wet), protect bridge abutments against scour, protect major riverbanks, riverbeds, and waterways against floods.
The TechRevetment solution was marketed by the Reinforced Earth India teams to curb erosion of the banks of the Coimbatore municipal reservoir. Since this reservoir is the only water supply source for the city, the main constraint was having to install without emptying it.

• The Solution

The TechRevetment solution provides long lasting embankment erosion control by combining a geosynthetic mattress filled with concrete with a non-woven geotextile filter.
The TechRevetment solution consists of covering the surfaces under threat by erosion with a geosynthetic mattress. Once the mattress is installed on the stabilized surface, it is filled by gravity with a mortar. After the mortar has cured, it will act as a protective barrier. Drainage pipes also balance hydrostatic pressure.

• The Advantages

Its unique underwater installation system saves valuable time. In the case of the Coimbatore reservoir, 1.2 kilometres of bank revetments were protected in a record 17 days.
Winner of the 2017 Soletanche Freyssinet Innovation award in the category of News Market, the TechRevetment solution is a first for the Terre Armée Group which continues to diversify its applications in numerous fields.

AROUND THE WORLD

RETAIN

France
JONCET BYPASS

In the village of Joncet, Terre Armée was involved in work on the RN 116 bypass, designing and supplying 6,200 m² of walls with the TerraTrel® solution. The bypass was officially inaugurated on June 2018.

AROUND THE WORLD

Burkina Faso
OUAGADOUGOU'S NORTHERN INTERCHANGE

Terre Armée France designed, supplied and provided technical assistance for 12,000 m² of Reinforced Earth® access ramps for this interchange situated on the north-western tip of the city's beltway. The project should be completed at the end of 2018 and will contribute to ease traffic flow in this highly congested urban area.

Philippines
MACTAN CEBU AIRPORT TERMINAL 2

In Cebu, Reinforced Earth Malaysia and Freyssinet Manila Inc., its sister company, worked together on the construction of the first Reinforced Earth® true abutment in the country with 7 MSE walls for the new international terminal of Cebu Airport.

Peru
UCHUMAYO MOTORWAY

In Arequipa, Tierra Armada Peru sensibly optimized delivery times and costs of the Uchumayo motorway works by designing, supplying and supervising the installation of 45,000 m² of TechWall® walls.

Morocco
SIDI MAÂROUF BRIDGE ACCESS RAMPS

In Casablanca, Freyssinet Morocco and Terre Armée Morocco have collaborated on the construction of the cable-stayed bridge at Sidi Maârouf. Terre Armée has constructed two access ramps made of Reinforced Earth®, supported by TerraClass® facings and Geostrap®5.

Canada
REGINA BYPASS

Reinforced Earth Canada is finalizing the design and supply of 44 MSE walls on the Regina Bypass project for the Province of Saskatchewan. A total of 11,800 TerraClass® panels were required to be fabricated and shipped to the project. Work is planned to be completed by 2019.

AROUND THE WORLD

Chile
7 REINFORCED EARTH® WALLS FOR THE NEW ACCESS ROAD OF THE TOWN OF IQUIQUE

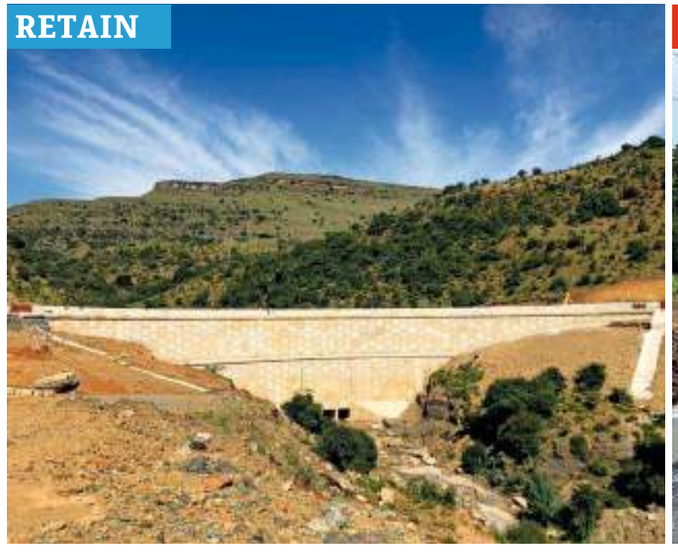
In northern Chile, Tierra Armada supplied 40,000 m² of retaining walls for the new road that will connect Iquique to Alto Hospicio thanks to the new Pan-American highway. This 9-phase project was completed in July 2018 with the installation of the last panel, the final element of the largest wall ever built in South America, with a length of 2,700 meters.

Poland
EXPRESSROAD S51

Freyssinet Polska is supplying 11,400m² of Reinforced Earth® structures for S51 Olsztyn - Olsztynek Expressroad. With the opening planned for 2019, the road will provide a safe link between the tourist region of Warmia-Mazury ant the Capital city, Warsaw.

Venezuela
CINTA COSTERA

In Vargas State, Freyssinet-Tierra Armada Venezuela is participating in the Cinta Costera ("Coastal Route") project with the construction of 14 walls of Reinforced Earth®, decorated with allegorical marine figures. With a length of 17 km, this coastal esplanade will feature a variety of restaurants and sporting and cultural facilities.



South Africa
MODERNIZING THE LINK BETWEEN TWO SOUTH AFRICAN PROVINCES

In the Kwazulu Natal Province, Reinforced Earth (South Africa) is taking part in the upgrade of 50 km of rural gravel road to a tarred surface road with MSE walls. Originally intended as a 155m long bridge spanning across the gorge, the Reinforced Earth® design proved a far more economical solution comprising 2 two- tiered walls back-to-back with a total combined height of 19 meters.

Panama
THE FIRST REINFORCED EARTH® TRUE ABUTMENTS

In Panama, Freyssinet - Tierra Armada is building the first Reinforced Earth® true abutments on two of the capital's bridges. The project got under way in January 2018, and includes the construction of four true abutments that were designed in conjunction with Tierra Armada Mexico. A total of 5,045 m² of walls will be installed, with GeoStrap®5 & 9 reinforcements. The work is scheduled for completion in late 2018.

Major project

STAMPEDE DAM

PROTECT

RETAIN

TerraPlus® panels installation.

The essentials

— The project Raising the Stampede Dam in order to increase reservoir capacity.
— Reinforced Earth USA missions Design, supply and technical assistance for 10,000 m² of TerraPlus® panels.
— Duration 16 months.

UNITED STATES

Raising the Stampede dam with TerraPlus® walls

Located at an altitude of 1,800 m in the Sierra Nevada mountains of northern California, the main purpose of the Stampede dam is to prevent flooding and conserve protected species. The US government embarked on the project to raise the crest of the dam in 2012 in order to enhance the safety and storage capabilities of the structure, which was built in 1970. The general contractor awarded Reinforced Earth the contract to design and supply the 10,000 m² of TerraPlus® facing panels required for the structure.

Challenges and adaptation

In August 2017, the first back-to-back TerraPlus® facing panels were assembled along along the crest of the dam.
To successfully complete their mission, Reinforced Earth's engineers had to take into account the constraints linked to the various purposes of the raised section. They had to assess the submergence and shrinkage loads in the event of a major flood, while anticipating the moving loads on the crest structure, which is also used as an access road. Finally, the seismic coefficient was 1.2 g, due to the type of soil and large earthquake potential in California.

Safety and performance

Intended to limit dangerous outflows during significant flood events, the aim of the raising work is to protect the surrounding towns and tourist destinations and increase the storage capacity of the reservoir rim by almost 4 million cubic metres, while carrying an access road.
The project is funded by the Dam Safety Program run by the Bureau of Reclamation, a federal agency under the US Department of the Interior, which is supervising the project on behalf of the United States government. Work is scheduled for completion in October 2018.

10,000
square meters
of TerraPlus® facing

The partners

— Customer United States Department of the Interior, Office of the Bureau of Reclamation.
— Engineering United States Army Corps of Engineers.
— Project manager NW Construction, Inc. (Bozeman, Montana).

JACQUES BLOOMFIELD,
WESTERN DIVISION MANAGER.

"This project is a prime example of dedicated long-term follow through with the client from early conceptual stage, all the way through construction. Our Business Development, Engineering, Regional Sales, and Operations departments demonstrated teamwork and expertise in all phases of the project. In the end, the client was delivered the optimal solution that addressed all of the challenges of such a remote and critical structure."

Download our Dam & Reservoirs brochure.

16 APPLICATIONS

The techniques developed by the Terre Armée group are particularly suited to many market segments.
The various applications of our techniques are the following:

- Airports
- Dams & Reservoirs
- Energy
- Environmental
- Industry
- Land development & Building
- Military
- Mining & Minerals
- Oil & Gas
- Ports & Coastal works
- Railways
- Rivers & Waterways
- Roads & Motorways
- Sports & Leisure
- Waste management
- Water management

ROADS & MOTORWAYS

RAILWAYS

100 meters
High wall.

9,700 square meters
of TerraLink®.

Active hill slope stabilization using TerraNail® and FreyssiAnchors.

HILL SLOPE STABILIZATION AND ROAD RECONSTRUCTION IN TINDHARIA

Reinforced Earth India has been awarded a major landslide restoration project after a significant earthquake in 2011. Located in Tindharia, in the lower Himalayan region of West Bengal, the landslide had washed away the Siliguri – Darjeeling road and was putting the 100-year-old Darjeeling Himalayan Railway at the risk of collapsing.

Tailored Reinforced Earth® solution

Initially the client decided to build a 100 meter high Reinforced Soil steep slope with gabion facia and geogrid soil reinforcement, but this proposal was not successful due to a requirement of a huge quantity of backfill. After studying the geometry, geology and making a logistical assessment, Reinforced Earth India proposed the use of a TerraLink® Structure, which reduced the backfill quantity to almost 1/6th of the initial proposal. This concept was accepted by the client that offered Reinforced Earth a contract.

Technical challenge

Reinforced Earth India used TerraNail® and FreyssiAnchors® (Freyssinet Ground Anchor System) with GeoTrel™ facing and High Adherence GeoStrap®5 in their proposed solution. With a height of 100 meters, this project is unique in terms of technical challenge and shall be one of the highest MSE structures in the world, once completed.

Huge project with access constraints

The high steep slope was one of the major challenges leading to difficulty in access of machinery and other resources on the site. At certain locations, drilling machines were supported with a hanging arrangement such as wire rope and a winch while operating it. Due to the constricted width of the main carriageway at the top of the working zone, vehicle movement was required to be controlled. Drilling at the bottom of the structure was extremely difficult, due to the presence of accumulated rain water or sub-surface water. Eventually, inclement weather condition would be another challenge since the rainy season continued for almost 6 months leading to a very small working period in this area. Work is scheduled for completion in December 2019.

The partners

— **Customer** Ministry of Road Transport and Highways
— **Engineering** Xplorer - TSPL JV
— **Project manager** GPT-SSPL JV

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ROADS & MOTORWAYS

TERRATILT® AND TERRACLASS® CONCRETE PANELS FOR THE NORTHLINK PROJECT

RETAIN

In 2016 the city of Perth embarked on highway construction work intended to meet the needs of a rapidly growing population. This large-scale project entitled NorthLink WA will provide the region with a safer and more extensive road network by 2019.

A major project

Reinforced Earth Australia's role in this massive project is the design and supply of TerraTilt® and TerraPlus® precast concrete panels. Divided into three phases, NorthLink WA consists of both upgrading existing links and the construction of new highways. Having successfully completed its first mission in phase one, Reinforced Earth Australia has won further contracts for the remaining two phases of the project. A total of 31,000 m² of TerraTilt® and TerraPlus® concrete panels will be provided for the NorthLink project.

Cost and time savings

Offering savings on equipment and costs, as well as in terms of time, Reinforced Earth® solutions once again prove their effectiveness and durability. Reinforced Earth Australia also provided the design and supply of two temporary walls giving the flexibility to the client to build part of the bridges while maintaining an open highway at all time.

The essentials

— Phase 1: Southern section
Design and supply of 3,500 m² of TerraTilt® facing panels on three bridges.
— Phase 2: Central section
Design and supply of 12,000 m² of TerraTilt® facing panels on ten bridges.
— Phase 3: Northern section
Design and supply of 16,000 m² of TerraTilt® facing panels and TerraPlus® modular facing panels on several bridges and retaining walls.

TAJ GOULD, MSE WALLS MANAGER, GRAHAM CONSTRUCTION
Regina Bypass Project, Canada

«Working with Reinforced Earth was very beneficial»

Graham Construction is the leading Canadian Construction company and part of the consortium of the Regina Bypass project, the largest transportation infrastructure project in the province's history. In 2015, Reinforced Earth Canada was chosen by the main contractor to supply 44 Reinforced Earth® structures.

A few questions to Taj Gould, MSE Wall Manager of Graham Construction.

Terre Armée Magazine: What are the main challenges that you faced on project Regina Bypass, whether technical, industrial, environmental, site related, planning related?

Taj Gould: With a project this size, one of the main challenges has to be coordinating personnel, material, equipment and the availability of work space. With the amount of MSE walls spread out on this project, coordinating with Reinforced Earth was crucial to ensure we have the material where we needed it when we needed it.

T.A.M: What made you select the solution proposed by Reinforced Earth? What main differentiating factor set it apart from the others (innovation, costs, planning…)?

T.G: Our decision to work with Reinforced Earth Canada for this project was based on the strength of their technical proposal.

T.A.M: What were the main benefits of working with Reinforced Earth on this site? How did you work together to find human or technical solutions, solve difficulties? What are the main highlights of this collaboration?

T.G: Working with Reinforced Earth was very beneficial. With every issue or conflict encountered on the project, we were able to communicate with Reinforced Earth and work on a proposed solution, with small issues or conflicts being handle almost immediately, while other larger problems were resolved within 3 to 5 days. As well as with all the design changes due to field fits and site instructions, Reinforced Earth was able to provide technical support, revised drawing and details with very short turnaround time. They were even able to provide same day onsite assistance for major conflicts if required, all while working over 8 hours away from the job site.

T.A.M: Are you satisfied with the quality of the work done? What added value did Reinforced Earth bring to this project?

T.G: Yes, we are very satisfied with the work and workmanship Reinforced Earth had provided. They were able to add value through their many years of experience found in their organization. They were able to provide comments, recommendations, supporting documents and general correspondence to assist RBDB with technical discussions with the owner and their representatives.

T.A.M: What are the main positive points of this collaboration? What 3 adjectives better describe your relationship with our teams?

T.G: The employees are very knowledgeable and quick thinkers. They are very professional on and off site. Their willingness to provide assistance and go above and beyond their contractual obligations have been essential to keep the project moving forward.

The year

1969

More about our Bridges applications.

Construction of the world's first true abutment in Strasbourg

Just one year after the company was founded, Terre Armée built the world's first true abutment in Strasbourg, France. Simultaneously a retaining wall and load support, the structure takes the load of the bridge deck without the use of piles. Following the project, studies were performed in the United States and Europe to confirm the concept and the design methods still used at Terre Armée today.

Around the world...

...On 20 July

Neil Armstrong became the first man to walk on the Moon. Live and in front of over 600 million people, the astronaut took his first steps on the moon before planting an American flag, helped by his co-pilot Buzz Aldrin. «That's one small step for (a) man, one giant leap for mankind,» he said.

...In August

Almost 500,000 spectators came together for the Woodstock Music & Art Fair. The event was billed as three days of peace and music by the organizers, who ended up extending it by a day because it was such a success.

The Soletanche Freyssinet Group

SOLETANCHE FREYSSINET

The Group brings together an unrivaled set of skills and brands in the construction and engineering sector. Soletanche Bachy, Menard, Terre Armée, Freyssinet, Nuvia and Sixense apply their technical excellence to enhance the performance and service life of structures.

22,100 employees

80 countries

6 compagnies

FREYSSINET

KPEME WHARF

Freyssinet is currently carrying out restoration work on Kpeme wharf in Togo. In service since 1961, the wharf is one of the major installations belonging to Société Nouvelle des Phosphates du Togo (SNTP), which operates the country's phosphate mines. Due to the saline environment and a lack of maintenance, the wharf is suffering from a number of defects that put its operation at risk. Freyssinet's teams are restoring the wharf with the aim of giving it a service life of approximately 15 years. The work is scheduled for completion in December 2019.

SOLETANCHE BACHY

SINGAPORE – TUNNEL NORTH-SOUTH CORRIDOR

The Singapore Land Transport Authority (LTA) has awarded the design-build contract for a section of the North-South Corridor (NSC) to the Penta-Ocean Construction Co Ltd and Soletanche Bachy Singapore Pte Ltd consortium. Penta-Bachy JV will design and build a 1.04-km tunnel, together with user facilities including an underground pedestrian network, pedestrian bridges, bus stops, a covered walkway and cycle paths, between Suffolk Walk and Novena Rise. Work should start in the first quarter of 2019.

sixense

GUADALAJARA METRO

New metro: real-time monitoring to conserve historic landmarks. Sixense carried out the instrumentation works in the Guadalajara metro tunnel, its five stations and all surface buildings along the line. The Mexican Ministry of Transport and Telecommunications initiated the real-time monitoring system in order to monitor and better conserve landmark buildings. The teams brought their added value to the design by suggesting a comprehensive detailed analysis. The dynamic and responsive teams succeeded in installing the comprehensive automated instrumentation in the buildings while the tunnel boring machine was operating at full capacity.

NUVIA

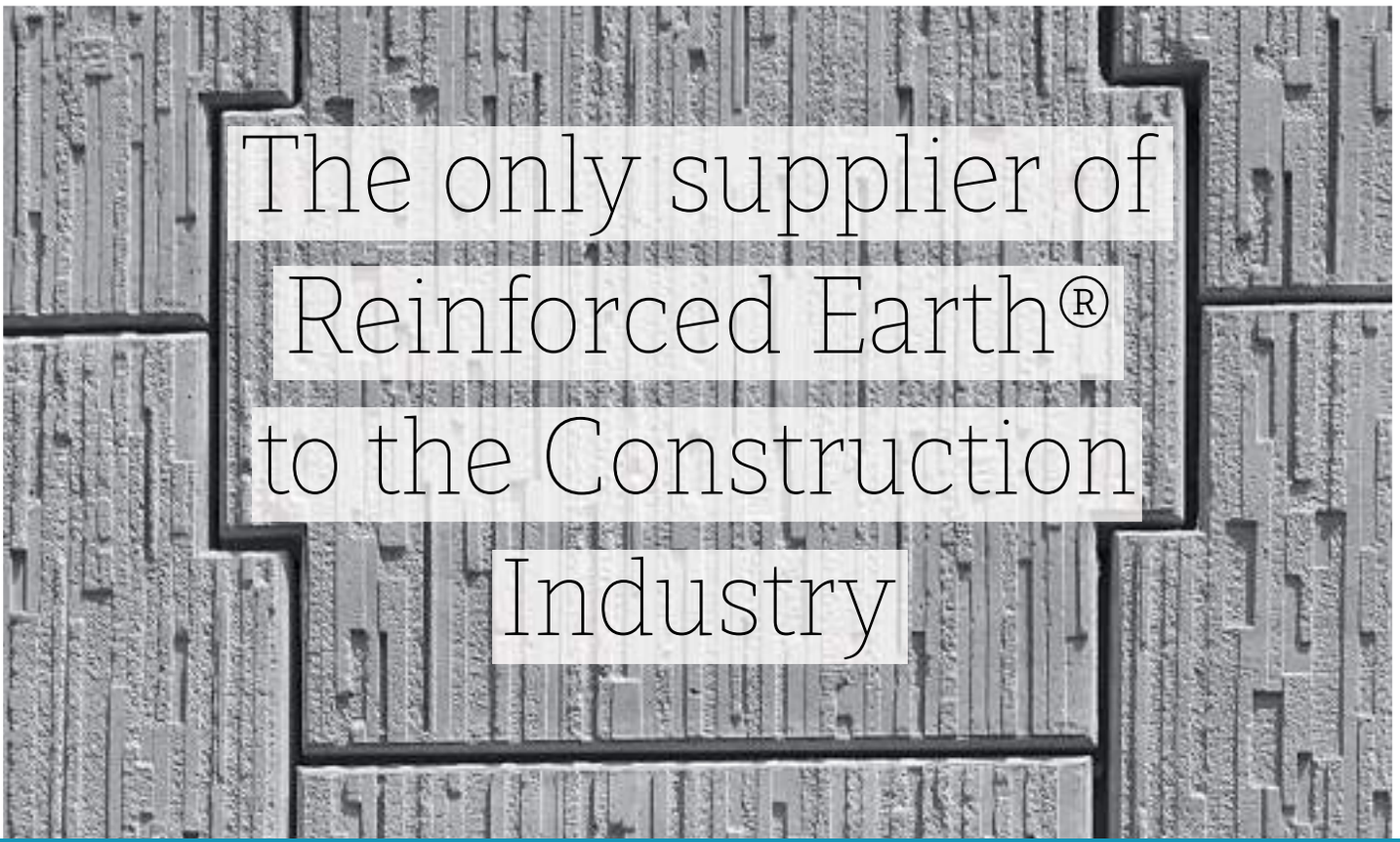
NAVARRO: A «BACKPACK» SPECTROMETER TO MONITOR ABANDONED URANIUM MINES

In the U.S., Navarro Research and Engineering Inc. used four portable Nuvia Dynamics (formerly PICO Envirotec) gamma ray spectrometers to assess a former uranium mining site in Colorado and Utah prior to its opening to the public. Because the system is carried in a backpack it facilitates spectrometric monitoring. It can be used in slow motion if need be. The device is self-calibrating, stabilizes on natural gamma ray peaks and the data collected is automatically synchronized in real time by GPS.

menard

PORT OF BREST

In order to maintain the competitiveness of the Port of Brest, a vital component of the regional economy, and transform it into a leading site for renewable marine energy-related industries, a consortium made up of VINCI Construction Maritime et Fluvial (lead contractor), VINCI Construction Terrassement, Menard and GTM Ouest is involved in work to build a new 40-hectare port terminal. This extensive scheme includes building a quay, creating a heavy-load area and an enclosing dam (covered by another contract) for the future polder, part of which will be reclaimed from the sea, and improving the boundary between the town and the port with new landscaped public spaces. Work commenced in 2017 and is expected to last three years.



The only supplier of Reinforced Earth® to the Construction Industry

We patented the Reinforced Earth® technique in 1963.

Over the last 50 years we have:

- **forged an unrivalled level of experience and expertise** in reinforced backfill applications
- **set the standards** in the technique
- **played an active role** in over 50,000 projects worldwide.

Registered trademarks protect the company from others wishing to supply Reinforced Earth® services and products under the Reinforced Earth® banner.

REINFORCED EARTH