

Rennes Metro A long-lasting involvement

The DODIN CAMPENON BERNARD-SPIE BATIGNOLLES TPCI-GTM OUEST-LEGENDTRE OUEST-BOTTE FONDATIONS-SPIE FONDATIONS consortium is contractor for the construction of line B of the Rennes Métropole automatic metro urban transit system, within the framework of works package 1 comprising 8.1 km of tunnel (bored with a tunnel boring machine), 9 stations including 2 interconnecting with the existing line A, the TBM starting shaft and 4 ventilation and emergency shafts.

The TBM has now (end-November 2015) reached the second station, having passed through the first station in May, and a ventilation and emergency shaft in July. It has reached a bore length of 1.9 km. The tunnel is being bored through a geological context characterised by a very heterogeneous and variable substratum, consisting essentially of a number of Brioverian schist facies, overlain by various thicknesses of substratum alteration (alterites), alluvia and colluvia.

TERRASOL was contracted by the consortium to provide assistance during the tendering process, and has subsequently been working on the geotechnical engineering studies in the execution phase. In parallel, A. Guilloux is working as an expert consultant and participating in the project technical committee.



Photo credit: © Francis Vigouroux

In the design phase, TERRASOL carried out the geotechnical engineering studies: definition of the additional soil testing campaign and drafting of the geotechnical synthesis and assumptions for the design of the retaining structures and of the foundations.

TERRASOL was subsequently awarded an additional contract for estimating the settlements under the buildings in proximity to the stations excavation works, using 2D finite element calculations (Plaxis software), with the following objectives:

- revision of the settlement thresholds associated with the buildings vulnerability studies;
- decision support in the context of the design solutions to implement for the stations retaining structures (updating of the numerical model on the basis of the measurements carried out during the stations works, iteration on the retaining structures options with the contractor's design office).

TERRASOL has also been working for the last two years in the Works unit reporting to the consortium's technical management: an experienced engineer seconded full time on site is responsible for the geotechnical and geological follow-up of the excavation of the stations and the boring of the tunnel by the TBM. In direct relation with the monitoring managers, the retaining structures manager, the geotechnical risk matrix manager and the technical management, he acts essentially as the geotechnical advisor for the project as a whole. In view of the multiple issues encountered with both the tunnel and the stations, a second TERRASOL engineer was seconded at the end of June 2015 as reinforcement on the operational aspects of geotechnical and geological follow-up of the stations excavation works and on the definition and follow-up of the additional investigations.

In addition, for the last year additional finite element calculations (Plaxis 2D) have been run to update the geotechnical models with respect to the building monitoring results and the station walls movements on the one hand, and to the changes in the retaining structures design proposed during the works (iterative calculations), on the other hand. These additional studies have, for example, led to the definition of hydrogeological models for estimating

Editorial

In 2015 Terrasol's activity has again been very sustained, with a wide range of projects as always. We are of course working more than ever in the area of urban transportation, in particular in the context of the Greater Paris project, to which we are geotechnically contributing at various levels (assistance to project owner, project management, assistance to contractors) on a number of sections and lines, but also for instance in Rennes.

In parallel we are continuing the development of our activities: in the field of energy, for example (Boutferda hydroelectric project in Morocco, geotechnical assistance to Alstom on a number of power plant projects, involvement in the UK EPR project, geo-energy structures – see the 2015 special issue of our newsletter dedicated to energy projects), or internationally in general, with a firm push to have a stronger presence alongside local stakeholders.

And we are particularly pleased to announce a major step in the development of our activity in Morocco, with the recruitment of an experienced geotechnical engineer in the country: Tarik El Malki is now at your disposal to assist you with the geotechnical aspects of your projects in Morocco. He naturally benefits from Terrasol's calculation tools and from our support in terms of geotechnical expertise.

Lastly, new versions of our software are being rolled out, incorporating a number of innovating features, such as risk analysis in Talren v5 and many extended calculation options in K-Réa v4.

With our best wishes for a peaceful 2016,

V. Bernhardt

the effects of the water level lowering in relation with "complex" hydraulic circulations.

Lastly, considering the issues and the retaining walls displacements observed at one of the interconnection stations with existing line A, in spring 2015 TERRASOL was contracted to carry out a 3D modelling of the station under construction: 3D modelling of the new and existing stations, the tunnels and the connecting passages.

P. Legrand, C. Jeu and A. Bachelier

Coastal reinforcement in Cape Lopez

Gabon



Photo credit: Total Gabon

Cape Lopez is the point of Mandji island, Gabon, extending the furthest into the Atlantic Ocean. It consists of mainly-sandy delta deposits, underlain by a very dense layer located at a depth of more than twenty metres.

The main ocean currents flow around the cape from West to East, carrying sediments eroded from the West coast towards the East coast. When they enter Princes' Bay, the currents are protected by the cape and slow down. Very fine sands, of very uniform grain size, are then deposited along the East coast, resulting in its growth. Submarine landslides of varying magnitudes (up to several million cubic metres) occur frequently on the East coast. The slides take place along very gentle slopes (less than 5°). A possible explanation of these recurrent landslides is that the relative densities of the local sands are lower than the critical densities. This makes them very sensitive to the generation of excess pore pressures, which may be referred to as "lateral spreading" phenomenon.

Under the action of growth or of any other load generating excess pore pressures, the sands lose their shear strength and flow. In this context, TERRASOL has worked with TOTAL SA and TOTAL GABON to reinforce the East coast, where erosion by recurring landslides is threatening the oil terminal located on Cape Lopez.

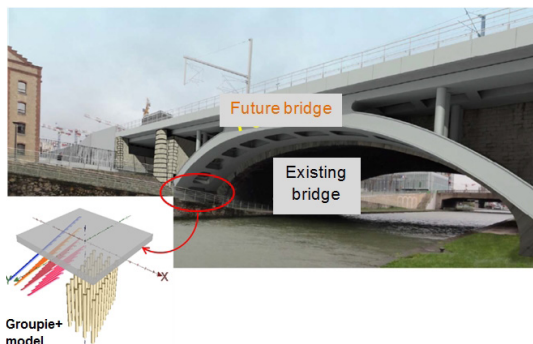
TERRASOL carried out the studies for the basic engineering phase, covering the choice, the definition and the justification of the technical solutions to be implemented. Two areas were particularly concerned by the implementation of the protection system: the area of the beach to the north of the facilities, accounting for two-thirds of the coast to be protected and which is some distance from the vulnerable structures, and the area of the old quay, which extends for 200 metres along the coast and is located in the immediate vicinity of the oil terminal facilities.

The studies conducted by TERRASOL will be used as the basis for the tender documents issued to the contractors, which will be awarded an overall design-and-build contract.

C. Babin, K.V. Nguyen, and M. Blanchet

Widening an existing railway bridge

Saint-Denis canal, France



TERRASOL has been contracted by SNCF RÉSEAU for the design of the foundations system of a composite-structure skew arch bridge on the Saint-Denis canal. The bridge structure is eventually intended to support two additional railway tracks by widening an existing masonry arch railway bridge. The operation as a whole is part of the EOLE project (extension of RER line E west of Paris).

The foundation principle which was chosen comprises a group of grouted micropiles capable of absorbing a resulting load inclined at 45° from horizontal. The extremely demanding settlement criteria imposed on the structure (due in particular to a new track straddling the existing and future bridges) led us to recommend a design taking account of soil-micropile-structure interaction effects in order to ensure strict consistency between the supports stiffness and the loads transmitted by the superstructure.

Application of the new capabilities provided by the Groupe+ module of the Foxta software developed by TERRASOL enabled easy analysis of the three-dimensional behaviour of all the micropiles interacting with the superstructure that they support.

F. Cuira

Pointe des Grives

Martinique, France



Photo credit: Balineau

Anticipating the operational opening of the widening of the Panama canal, scheduled for first-quarter 2016, the Grand Port Maritime de La Martinique (GPMLM) has started works to extend the Pointe des Grives container terminal at Fort de France.

The project comprises the addition of a backfilled platform covering nearly three hectares to the south-east of the existing facilities, which will be protected by a perimeter of 660 metres of riprap dike.

In a geological context dominated by marine alluvia with very poor mechanical characteristics, in a region also subject to a high seismic risk, TERRASOL has been contracted by BALINEAU to design a soil improvement system to be implemented under the dikes.

The favoured reinforcement system consists of an optimised network of precast rigid inclusions (in reinforced concrete), vibrated in from the platform under construction. A test plot is also planned in order to study a reinforcement system combining underwater compaction of a granular mattress with intercalation of driven steel sections.

F. Cuira and M. Hocdé

Stopping a water leak in the Lire Sud tunnel

Paris, France

The L.I.R.E. Sud tunnel (link between water reservoirs), connecting Porte de Sèvres and Porte d'Auteuil in Paris, accommodates a drinking water supply pipe 1200 mm in diameter belonging to EAU DE PARIS. The tunnel, internal diameter 3.1 m, was bored in 2001-2002 using an earth pressure balance (EPB) tunnel boring machine (TBM). The entire tunnel is bored through limestone.

The section crossing the river Seine and running parallel to the "Boulevard Périphérique" ring road was damaged in December 2014 by pile-driving works on the left bank of the river. A pile pierced the lining, opening a major continuous water inflow (flow rate of around 140 l/s), and damaged the drinking water pipe.

TERRASOL, which had assisted EAU DE PARIS when the tunnel was excavated, was contracted to define solutions for stopping the water leak and to follow-up the repair works.

The solution adopted consisted in partial flooding of the tunnel between two shields to stop the flow, then grouting from the surface to create a watertight plug over the entire overburden depth down to the tunnel invert; this was intended both to reduce the fracture permeability in the limestone and to eliminate the preferred path formed in contact with the pile that had damaged the tunnel and the limestone.

The grouting played its role perfectly by stopping the water inflows and providing dry conditions for the repair works on the tunnel voussoirs.



H. Le Bissonnais and J. Marlinge

Place Vendôme

Paris, France

Three historic buildings dating from the 17th century located Place Vendôme, in Paris, are undergoing restructuring. The works include substantial changes to the superstructure and the addition of another basement level. As part of this project for client UFIPAR (owner), TERRASOL is involved in the project and execution phases with BARTHÉLÉMY-GRİÑO ARCHITECTES and the structural engineering consultancy T/E/S/S.

Founded superficially in the old alluvia, these buildings have undergone substantial evolutions during their long history, particularly in their foundations. TERRASOL defined the specifications for the geotechnical investigations, including a number of excavations to survey the existing foundations, and followed-up these investigations. Following the preparation of a schematic diagram of the existing foundations, TERRASOL carried out the design for the underpinning works, taking into account the interaction between foundations, and the uplift forces generated in the micropiles by the water pressures.

The underpinning works with alternating lined shafts are now in progress. TERRASOL ensures the follow-up of these works, which are carried out in a space that is very confined in places and under thick sandstone and dressed stone facades.



B. Aksoy

Plomin thermal power plant

Croatia

The Plomin C project consists of the construction of a coal-fired thermal power plant on a site already accommodating two plants in operation in the Istria region of Croatia. Units 1 and 2 were built in 1969 and 2000, respectively, and Plomin C will double the capacity of the site, even after the dismantling of unit 1.

The Plomin C project includes the construction of a new production unit (on the present storage area), a new coal storage area, a harbour, a conveyor belt, a pumping station and a tunnel for the cooling system. The project location is in a geological environment consisting mainly of rock (limestone).

In this project, TERRASOL was contracted by ALSTOM to work on the drafting of a geotechnical analysis and preliminary design, on the preparation of the specifications for additional soil investigations, and on the analysis of these data for the structures design. The investigations have been carried out by the Croatian company IGH under the supervision of a TERRASOL engineer.



J. Drivet and C. De la Salle

Software Department

Talren v5.1.4

Foxta v3.2.4

Stratcad v1.4

K-rea v4.01

Plaxis 2D 2015.2

Plaxis 3D AE.01

K-Réa v4

The new version K-Réa v4 is now available for download from Terrasol's website. This update is provided free of charge to K-Réa v3 users. This new version especially includes a new calculation engine which has been developed by Terrasol and considerably extends the software's capabilities. Among the new key features:

- Direct processing of double-wall projects without iterations and with no limitation of the number of linking anchors;
- Calculation according to approaches 1, 2 and 3 of Eurocode 7, with ULS checks extended to double-wall projects (including Kranz);
- Automated processing of bank and berm effects according to Eurocode 7 recommendations;
- Possibility to impose user-defined active and passive soil pressure and water pressure diagrams;
- Automated processing of loads combinations;
- Consideration of seismic conditions.

And a new user-interface was developed to host this new calculation kernel.

K-Réa v4 – Double-wall project
Unlimited number of linking anchors.



XVI ECSMGE in Edinburgh
September 2015

Foxta v3

A new Foxta update was released in July 2015: it includes major improvements regarding Tasplaq module (ability to set a dip for soil layers) and Groupie+ module (automatic calculation mode). And for a few weeks, Tasplaq and Tasseldo modules have allowed to display the calculation output as shadings (instead of scatter plots).

Talren v5

In order to widen the use of Talren, especially abroad, a "Light" version of Talren v5 is now available. It includes all Talren features except for the reinforcements and for the yield design calculation method.

Conferences

- TERRASOL took part in the XVI European Conference for Soil Mechanics and Geotechnical Engineering from September 13 to 17, 2015 in Edinburgh, Scotland.
- We shall also be attending the « Journées Nationales de Géotechnique et de Géologie de l'Ingénieur » (JNGG) from July 6 to 8, 2016 in Nancy (France).

Our new agent in Spain

We are happy to introduce Geodeltia as our new software agent for Spain! Geodeltia will from now on distribute the whole catalogue of Terrasol's software (Talren, Foxta and K-Réa) to Spanish clients.

Please feel free to contact them for information or a demo: www.geodeltia.es / jl.huerta@geodeltia.com.



Recent publications and presentations

- Stabilité de pentes en sols indurés et roches tendres (**A. Guilloux**) – Revue Scientifique et Technique de la Construction N°130, 2nd semestre 2015
- Fondations du nouveau Tribunal de Grande Instance de Paris (A. Zonco, **A. Beaussier**, E. Lapie and D. Michel) – Travaux Magazine N°916, July-August 2015
- Prise en compte des géogrilles dans un modèle biphasique simplifié d'un sol renforcé par inclusions rigides (**B. Simon**) – XVIth European Conference on Soil Mechanics and Geotechnical Engineering (XVI ECSMGE), Edinburgh, September 2015
- Simple 3D modelling of soil-pile-structure interaction for a group of energetic piles (**C. Borely**) – EYGEC, Durham, September 2015
- Numerical back-analysis of the southern Toulon tunnel measurements: a comparison of 3D and 2D approaches (**JP. Janin**, D. Dias, F. Emerault, R. Kastner, **H. Le Bissonnais** and **A. Guilloux**) – Engineering Geology 195, September 2015
- Chantier de remplacement partiel des conduites forcées de Malgovert (**F. Binet** and **T. Rossi**) – Technical day CFMS «Travaux en montagne», November 2015
- Dynamic finite elements analysis of a breakwater under seismic and wave actions – A case study (**KV. NGuyen**, T. Jeanmaire, JM. Anfray, **A. Guilloux** and **J. De Cacqueray**) – 9th National Symposium AFPS, November-December 2015
- Apports de l'ingénierie géotechnique dans la conception parasismique des ouvrages : quelques exemples (**F. Cuira**) – 9th National Symposium AFPS, November-December 2015



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