

## The Excavation of the Croix-Rousse Tunnel (Lyon, France)

### Editorial

This newsletter will give you an insight into what we have been doing in 2011, by providing a few examples of projects to which we have contributed and the scientific and cross-disciplinary activities in which we remain actively involved (research projects in particular).

In 2011, TERRASOL's consulting activities relied on three main strengths:

- the healthy recovery of our services in the area of major infrastructure projects: High-Speed railway lines "East-European" and "Brittany - Loire Valley" and, to a lesser extent, the High-Speed line "South Europe Atlantic", as well as the Croix-Rousse tunnel in Lyon (see opposite), etc;
- the development of geotechnical consulting services for "industrial firms" in a broad sense;
- regular geotechnical assignments, whether it be for our external clients or within the Setec group.

This is set to continue in 2012, a fact that has led us to strengthen our teams at all levels, allowing us to look upon 2012 with added confidence.

Furthermore, TERRASOL is proud to announce the launch on the market of major updates of the Foxta and K-Rea software applications, which will provide users with new advanced calculation features that meet the latest standards (among which the Eurocodes), together with user-friendly interfaces.

But above all, we would like to make the most of this newsletter to wish all our readers a very happy 2012!

Happy reading and until next time,

A. Guilloux



The Croix-Rousse urban tunnel (a single-tube structure 1,753 m long) connects the Eastern and Western halves of the Lyon conurbation. This is an outdated structure that does not comply with current regulations. As part of its full renovation and the work required to bring it into compliance with European directives, a safety tunnel (known as the "North Tube") needs to be built. This tunnel will also allow to provide a link between the Rhône and Saône rivers for soft transport modes (pedestrians, cycles and buses).

Within the grouping represented by Dodin Campenon Bernard, and as part of work package 3 (Design and Integrated Project Management) managed by SETEC ALS, TERRASOL took care of geotechnical aspects at every stage of the project, not only with regard to design (preliminary studies during the invitation to tender, project design and external control of the detailed design), but also during the works phase when it came to the earthworks required at the tunnel portals and to the tunnel excavation itself.

The excavation of the North Tube began in September 2010 and ended on 15 September 2011.

The excavation works, which covered a distance of 1,726 metres, therefore took approximately one year: the construction of the portals, in loamy sand soil from the Miocene period, required the use of a roadheader and the installation of a heavy support structure (steel arches beneath forepoling that was not renewable on the Saône side and renewable over a distance of a hundred metres on the Rhône side). The remaining excavation work, which passed through a granitic and gneissic bedrock, was conducted with explosives (emulsion) and supported with a light bolted-shotcreted support. No major geological anomalies were encountered.

The project, which was executed in a sensitive urban environment, also benefited from a significant amount of monitoring work. In particular, an automated instrumentation system was installed on the Rhône side, allowing surface deformations at the site to be measured. The settlements, which totalled less than a centimetre, were shown to be as predicted.

B. Madinier and J. Voiron

## A tunnel through coral

Miami, USA

Terrasol was called upon by BOUYGUES to help them analyse the geotechnical conditions for the excavation of a tunnel under a channel of sea in the port of Miami. This 11 m diameter twin-tube road tunnel passes approximately 15 m below the channel bottom and through extremely heterogeneous coralline ground, including one layer with very poor properties. To date, no tunnel of this size has been built in Florida through this kind of geological formation, which is extremely difficult to investigate and test given the high fragility of some layers. A tough challenge for French (geo) technics!

A. Guilloux



## New power station

Toul, France

After the one at Pont sur Sambre, POWEO is building a new power station in Toul.

The construction of this 412 MW gas-plant (combined cycle) was entrusted to SIEMENS, which called on TERRASOL'S expertise to carry out the project's geotechnical surveys and monitor the foundations execution.

The size of the project and the geotechnical context required 32 boreholes, 40 CPT tests, 16 pile load tests (static vertical, static horizontal and dynamic).

After analysis of the results, TERRASOL designed the deep foundations (CFA piles) and monitored the execution (by SPIE FONDATIONS) of more than 9,100 m of piles, representing some 2,400 m<sup>3</sup> of concrete.

J. Drivet



## ASIRI, a successful long-term project

2011 saw the successful completion of the national ASIRI Project devoted to soil reinforcement using rigid inclusions. It was launched in 2005 after various exploratory studies, which had been conducted as of 1999 with the support of the IREX and the RGCU. Terrasol was involved in this collaborative research project for over 11 years, with Bruno Simon in charge of its coordination and technical management from the very outset.

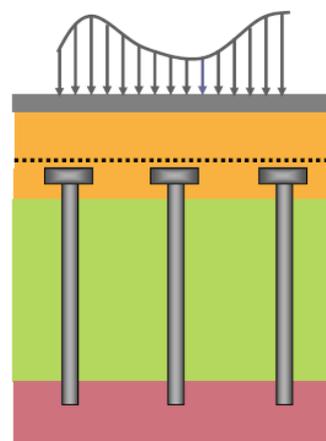
Strong commitment on the part of all 41 partners allowed the project to keep within the initial budget (2.4 million euros) while meeting the designated objectives: better understanding of behaviour mechanisms and drafting Recommendations for the design, execution and monitoring of these works. The 360-page document published at the end of 2011 by Presses des Ponts is the fruit of this work. Events held in Lyon, Paris, Toulouse and Nantes to present these Recommendations during the last quarter highlighted the interest this project has generated in the construction world by attracting over 400 people overall.

Terrasol's investment in this project has been considerable, its efforts equating to more than the annual workload of a full-time engineer since 2005. In addition to the project's scientific management and the coordination of experimental and numerical actions, numerous studies were performed in-house to assess the data from test sites, take part in benchmarking exercises, as well as develop and assess new calculation methods

suitable to this technique. Part of this work served to update the Foxta Taspie+ and Piecoef+ calculation modules. Several articles were also written to present simplified but effective methods, such as that used to calculate footings over rigid inclusions.

This project provides an exemplary illustration of what national projects can bring to civil engineering research as a whole, and geotechnical engineering in particular. The field of foundations is one very much open to innovation insofar as it is able to benefit from experimentation and players with complementary skills.

B. Simon



## ICSMGE "Paris 2013"

The 18th International Conference on Soil Mechanics and Geotechnical Engineering will take place from September 2nd to 5th, 2013 at the "Palais des Congrès" in Paris.

The conference's Organising Committee, setup by the French Committee for Soil Mechanics and Geotechnical Engineering (CFMS), has been hard at work for two years and has widely mobilised the French geotechnical community.

Terrasol is playing an active part in this project: A. Guilloux is Vice President of the Organising Committee, V. Bernhardt is the President of the Sponsoring and Exhibition Commission, and B. Simon is a member of the Scientific Commission.

V. Bernhardt

## Brittany - Loire valley High-Speed Line

Le Mans - Rennes, France

After a Public-Private Partnership contract was signed between "Réseau Ferré de France" and the EIFFAGE group for the construction of the new Brittany - Loire valley high-speed line), Terrasol has played a major role in working with the engineering teams led by SETEC since spring 2011. This has involved managing the geotechnical surveys and performing detailed design studies for part of the new line's engineering structures. A new experiment of major infrastructure project, within a new contractual framework.

A. Bergère

# Rebuilding a water-treatment plant

## Marquette-lez-Lille, France

The works to rebuild the Lille area's main water treatment plant commenced in November 2010 and are now in full flow. They are carried out by the grouping OTV France Nord - NORPAC - DEMATHIEU & BARD - AMODIAG - BONNARD & GARDEL - ALH, in the framework of a design&build contract. Having assisted the grouping during the bid phase, TERRASOL is now performing the geotechnical design (G2 to G4 missions) of the execution phase, as the geotechnical design office of the integrated Project Management team. We focused mainly on the foundations of the different structures (buildings, large treatment tanks, storage facilities, etc), which, given the loads applied and the poor mechanical soil properties on site, require the techniques implemented to be adjusted on a case-by-case basis (shallow raft foundations, piles, micropiles, etc).

J. Marlinge



# Development of an oil field

## Amazon, Peru

The "Block 67" oil field project will be developed in North-Eastern Peru, in the heart of the Amazonian Forest between the Andes and the Guiana Shield. The operation involves a limited number of platforms so as to minimise environmental impact. The extracted fluids will be collected and processed in a production plant before being exported.

The initial phase of the project consists in the development of just a single field, named Piraña. It includes two well platforms and a production plant, as well as the creation of a terminal on the Curaray River for the loading and unloading of fluids (for transportation to Manaus, where they will then be exported via a pipeline).

TERRASOL was called upon for the provision of G2 geotechnical services to DORIS ENGINEERING, which had been contracted by PERENCO PETROLEUM LIMITED to perform the engineering work for the oil field's initial development phase.

TERRASOL's mission included:

- drafting specifications for earthworks / backfilling, roads, car parks, basins, ditches and additional geotechnical surveys;
- producing design reports relating to the foundations of the platforms and the production plant, to the retaining walls required along the Curaray river, as well as to the drainage system (design subcontracted to Hydratec).

The major part of the work was carried out in direct interaction with the project team of DORIS ENGINEERING, for an optimised design process.

A. Bergère



# East-European High-Speed Line

## Saverne, France

Works on section H of the LGV EE (East-European High-Speed Line), from Danne-et-Quatre-Vents to Vendenheim (East of France), took an important step forward in 2011: all work packages were allocated and started, while work also commenced on the most emblematic structure of this second phase, the Saverne tunnel. Work packages 43a/43b, covering "Standard section", made the most of a favourable year for performing earthwork. "Viaduct" work packages 48 and 49 will enter the active work phase in early 2012.

Work package 47 involved earthwork at the tunnel's east portal to allow excavation of the first tube to commence in early November 2011.

Together with SETEC, Terrasol is actively participating in the Project Management of the different work packages: the Visa assignment led by the Parisian teams, plus the secondment of two engineers to the site to monitor the works covered by work package 47: the Saverne tunnel and the special engineering structures.

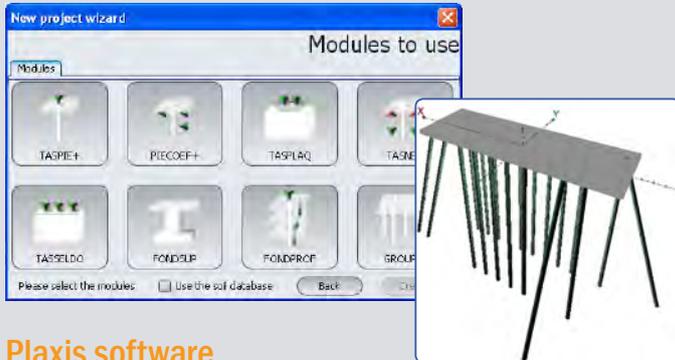
P. Legrand



# Software department

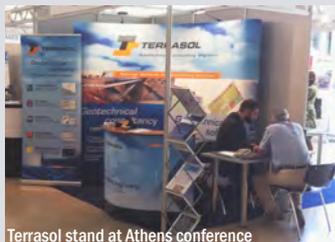
## Foxta v3 software

This new version of our calculation software for foundations and inclusions design has been available in French since November 2011. It includes a fully new and highly user-friendly user-interface and several major calculation new features: Tasplaq, Taspie+ and Piecoef+ (which enable for instance to carry out analyses of stiff inclusions according to new ASIRI recommendations). The English version will be released in 2012.



## Plaxis software

- The latest **PLAXIS 2D 2011** update enables to account for Euro-codes design approaches (management of partial safety factors)
- The latest **PLAXIS 3D 2011** version includes permanent ground-water flow calculation, and a wizard for circular shapes generation (tunnels)
- The **dynamic module** is now also available as an option for PLAXIS 3D 2011.



Terrasol stand at Athens conference

## Conferences

Terrasol attended the European Conference on Soils Mechanics and Geotechnical Engineering (ECSMGE) in Athens, September 2011.

We were also represented by our Algerian agent AMEDIC at the International Conference on Numerical Calculation in Geotechnical Engineering which took place in Algiers, November 2011.

You will get an opportunity to meet our team at the International Symposium "IS-Ground Improvement" (TC 211) that will be held in Brussels, from May 30<sup>th</sup> to June 1<sup>st</sup> 2012.



Talren 4 v2.0.4



Straticad v1.22



Foxta v3.0.2



K-rea v3.0.1



Plaxis 2D 2011.01



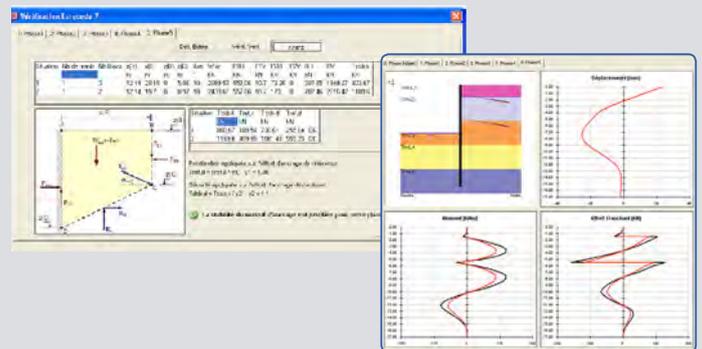
Tunren v1.05



Plaxis 3D 2011.01

## K-Rea v3 software

The new K-Rea v3 version was released in French in December 2011. It includes 2 major new features: ULS calculations and checks according to French Standard NFP 94-282 (French application of EC7), and calculation of double walls. It will be available in English shortly (beginning of 2012).



## Agents – Focus on Greece



NEOTEK (managing director: Mr Paris XYSTRIS) has been our agent in Greece for several years now. The conference in Athens was a nice opportunity for us to spend a whole week with Paris and his team, and to benefit from his technical know-how and his knowledge of the greek market. This will no doubt mark a strengthening of our partnership and we thank NEOTEK team again for their warm unrivalled welcome !

F. David

## Recent publications

- Rénovation lourde du tunnel de la Croix Rousse – Points particuliers de la conception technique (E. Clayton, B. Soler and **J. Voiron**) – AFTES Congress – Lyon, October 2011
- Tunnel de Toulon tube Sud : Injection de compensation sous deux bâtiments (**A. Guilloux, H. Le Bissonnais, R. Betend, G. Boyer**) - AFTES Congress – Lyon, October 2011
- Keynote lecture - Tunnelling in soft ground and urban environment (**A. Guilloux**) - Geotechnics for sustainable development - Geotec Hanoi Conference, October 2011
- A 3D Finite Element calculation of a raft foundation on reinforced ground (**K.V. Nguyen, P. Chalivat, A. Guilloux**) - Geotec Hanoi Conference, October 2011
- Performance of pile supported embankment over soft soil : full scale experiment (**B. Simon** and L. Briançon) – accepted for publication by Journal of Geotechnical Engineering – ASCE - 2012
- Contribution des logiciels de calculs géotechniques dans l'analyse de problèmes rencontrés sur chantier (**M. Yahia-Aissa**) - 2nd International Conference on Numerical Calculation in Geotechnical Engineering - NUCGE 2011 Conference - Algiers - November 2011



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