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Every year for the last 12 years, we have published our newsletter, 'La Lettre TERRASOL', to share with our clients and partners information about our recent activities: projects and works, upgrades in our geotechnical software, involvement of TERRASOL in research, publications, etc. This year, we decided to publish an English version of this 'Lettre TERRASOL' to facilitate communication with our English-speaking colleagues.

Let me first remind you that TERRASOL staff currently includes 45 employees and that our development, still in the field of geotechnical engineering, mostly covers major infrastructure projects or large buildings, with constant growth over the last 10 years. This engineering activity is divided equally between projects performed as part of the SETEC group, and our direct contracts with clients such as constructing companies and major owners.

The development of our 'Geotechnical software' department also matches this evolution.

One of the most important change over these last years has been the increase in our export activities (one third of our revenue in 2009), whether for our French clients on projects in foreign countries, or directly for international clients.

This 14th issue of the 'Lettre TERRASOL' presents a few of our recent achievements, from foundations to underground structures, whether in the frame of French or international projects.

We hope this first English issue will strengthen our relations with the international geotechnical community, and also contribute to spreading the French geotechnical culture throughout the World.

Alain GUILLOUX
Chairman and Chief Executive Officer

ALSTOM thermal power stations worldwide

Since the beginning of 2009, we have led various geotechnical studies for thermal power stations in France and in foreign countries on behalf of ALSTOM, a specialist in turn key facilities for power station projects.

Contact was established between the companies in 2006, when TERRASOL was entrusted by ALSTOM with an expertise on the geotechnical and hydrogeological behaviour of the Tucuman power station site, Argentina, to identify the cause of disorders (settlements) impacting the turbo-alternator unit.

In 2007, TERRASOL worked on the appreciation of the seismic input data to be considered in the studies of the Cycofos power station project in Fos-sur-Mer (France).

Since 2008, ALSTOM has regularly called upon TERRASOL's expertise to help in preparing offers (6 cases to date).

Many projects followed at the construction stage:

- Electrabel: GT26 420 MW combined cycle power station in Fos-sur-Mer (2008),
- Terga (Algeria): power station with a global power of 1200 MW consisting in 3 400 MW units (2008).
- Ghannouch (Tunisia): 400 MW combined cycle power station (2008-2009).

TERRASOL is leading geotechnical studies and offering geotechnical support during construction for the future power station in Ghannouch for example. Built for STEG (Tunisian company for Electricity and Gas), the main power producer and distributor in Tunisia, the power station will help

meeting most of power demands in Southern Tunisia.

The new Ghannouch power station is built next to the former one. The project is characterized by:

- loads at ground level corresponding to 0.25 MPa under certain structures (plant block, gas-steam turbine),
- an unfavourable geotechnical context marked by the presence of a fill layer made of silty sands above fine to coarse sand, with low geotechnical properties, encountered down to 11m deep below groundlevel.

To limit settlements to allowable values (2 cm) for these structures, the foundation type was chosen to be a piled-raft system made of concrete precast driven piles (0.45m*0.45m) bound to the raft foundation.

The foundation system was designed using TASPIE+, based on the assumption of an equal settlement of the soil and the inclusions below the foundation, negative skin friction due to soil settlement being transferred to the piles. This design has led to over 900 piles driven below the main buildings.

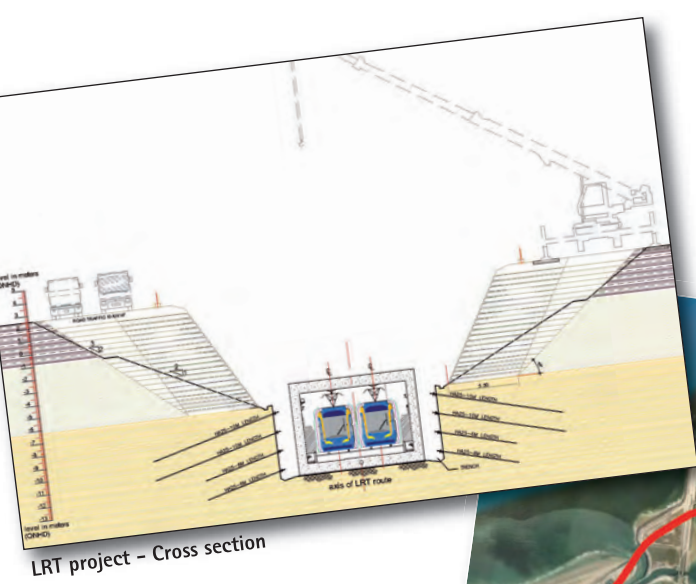
Finally, finite element models allowed to validate the settlements under the structures and the impact of earthworks and water drawdown by drive points close to existing buildings.

Our present mission consists in providing geotechnical support during the construction of the driven piles and temporary supports.

J. Drivet
A.-L. Fauroux



Driven piles project - Ghannouch power station (Tunisia)



LRT project - Cross section



Chavanne tunnel



Hydraulic gallery for the LNG terminal in Dunkerque

Qatar

LRT Project: Light Rail Transit System

TERRASOL is intervening in QATAR, on behalf of VINCI, within the LRT project (Light Rail Transit System) connecting the new town of LUSAIL to DOHA. The overall project includes 23 km rail tracks laying on the groundlevel and 7 km cut and cover, with a total of 29 stations. TERRASOL is in charge of a mission for studies of supports and reinforcements of excavation slopes the cut and cover zone.

The site is a reclamation area that was won over the sea and filled up by hydraulic filling; 10 to 15 m deep excavations are planned through the surface hydraulic fills, underlying compressible muds and silts, and down to the more or less altered marl and limestone substratum.

The retaining structures planned in the project include notably geotextiles reinforcements, soldier-pile walls and soil nailing, with major constraints related to water drawdown and limitations of earthworks rights of way.

P. Chalivat

Dunkerque

Hydraulic gallery for the LNG terminal in Dunkerque

The methane terminal in Dunkerque includes the following constructions:

- two tanks of liquid gas (LNG) each containing 190,000 m³,
- a harbour terminal for gas transportation ships (wharf), for about 80 methane tankers per year, with a capacity up to 270,000 m³ each,
- a regasification unit,
- a water inlet tunnel from the CNPE in Graveline to the tank area (tunnel of 3.0 m inner diameter and 5000 m long), to heat liquid gas.

TERRASOL was entrusted with engineering as an assistant to the project owner (EDF through its subsidiary DUNKERQUE LNG SAS) for the water inlet tunnel and the tunnel shaft (study and works).

The gallery will be constructed underground over 5 km, using an earth pressure TBM, and remaining in the same geological layer at all times (Flanders clay). The overburden will be about 45 m on the Graveline side. The tunnel will cross the West outer harbour.

Access to the tunnel will be provided by a 16m diameter and 45m deep diaphragm wall shaft.

The construction will be performed over 3 years, from 2010 to 2013 (call for tenders in progress).

H. Le Bissonnais

HSR Rhin Rhône

EAST branch Chavanne tunnel

Within the project management of the works of section C for the High Speed Railway "LGV Rhin Rhône", entrusted by RFF to the SETEC group, TERRASOL has ensured the geological and geotechnical monitoring of the excavation of the Chavanne tunnel. Excavation operations were performed according to the planned schedule. The two working faces joined on 28 January 2009, in the compact marl formations of the Toarcian.

This tunnel project (over 1970 m long) is characterized by the marly nature of soils encountered over the 2/3 of the linear. These soft rocks have shown, during project studies led by TERRASOL, very high swelling pressures leading to design adjustments (strong thickening of the raft foundation), and imposed excavation methods reducing exposure of soils to water in the raft area.

The excavation was performed by blasting in the limestone and stiff marl, and by mechanical excavation in marl areas where immediate stability was reduced by the use of explosives. The good short term behaviour of the marl materials allowed the constructing company to favour support by bolts and a fibered shotcrete shell (30 cm thick).

Geological surveys during works progress confirmed the geotechnical prognosis prepared by TERRASOL during studies.

S. Curtil



"Fondation Louis Vuitton pour la Création" model : south facade
(photo credit : Fondation Louis Vuitton – N. Borel)



"Fondation Louis Vuitton pour la Création" model : north facade
(photo credit : Fondation Louis Vuitton – N. Borel)

Eurocode 8 and HSR Paris

HSR projects adapted to a new regulation

The change in regulations planned for the near future, about how to design and build geotechnical structures for transport infrastructures under seismic conditions, has led RFF and its project owners to initiate specific studies to anticipate these changes.

In the "LGV Est Européenne" and "LGV Bretagne Pays de Loire" projects (high-speed railways in France), TERRASOL has led specific studies to compare the design of structures as per AFPS 90/92 and PS92 on the one hand, and Eurocode 8 on the other hand.

These studies covered earth structures (cuts and fills), as well as technical embankment of viaducts located on inclined slopes.

These comparison studies show that integration of these new Eurocode 8 regulations, but also of the new seismic zoning of France, has potentially led to an almost systematic reduction of the calculated safety factors.

Indeed, the "LGV Est Européenne" project required adaptations, by extending a viaduct and increasing quantities of constructive provisions for stabilizing embankments on loose soil.

C. Lefevre

Fondation Louis Vuitton pour la Création

The "Fondation Louis Vuitton pour la Création" is a prestigious project currently being constructed at the Jardin d'Acclimatation in Paris.

Its construction was entrusted with the architect Frank Gehry, author of many prestigious projects, including the Guggenheim museum in Bilbao.

More modestly for the geotechnical part, it is still an exceptional building, both by its structure and size, imposing very strict constraints on the foundations, and because it is built inside a 7500 m² and 15m deep excavation.

This excavation is protected by diaphragm walls and is now complete, without any particular difficulties. However, the design of the raft foundation is more sensible, due to the presence of deformable clay layers of the Sparnacian, False Clay and Plastic Clay, located 6 m below the raft foundation.

Although stresses are globally balanced between excavated earth and loads transferred by the building, the structure induces load concentrations exceeding initial stresses, whereas other zones are unloaded.

This is a new opportunity to develop 3D numerical modeling for accurate settlements analysis, where time effects must be considered. A geotechnical issue not much different from that of the nearby towers in La Défense.

A. Guilloux



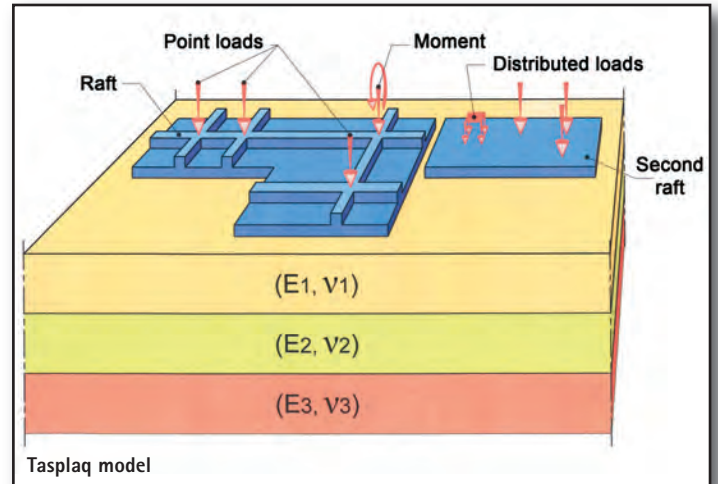
"Fondation Louis Vuitton pour la Création" excavation

SOFTWARE DEPARTMENT

Recent events include:

- Distribution of the (free) update of Talren 4 v2.0.3.
- Distribution of the (free) update of K-Rea v2.3.2. This version is bilingual French/English.
- Two new Foxta calculation modules were first marketed in June 2008: Taspie+ (calculation of isolated or grouped piles, rigid inclusions and piled-raft foundations) and Tasplaq (calculation of raft foundations on multi-layered elastic soils). The Tasplaq module will be available in English by September 2009.
- Organization of training sessions in France and foreign countries: Talren 4 training sessions in Paris and Manchester (UK), Plaxis v8/K-Rea training session in Tunisia. We also have a lot of requests for in-house training, with over 20 training sessions in 2008 about Terrasol and Plaxis software.
- Exhibition stands during several international conferences: St-Petersburg (Russia), IACMAG 12 in Goa (India), AFTES Congress in Monaco, etc. We have also been represented by our agents abroad in different local conferences (Turkey, UK, India, Mexico, etc).

In October 2009, we shall be present at the International Conference on Soil Mechanics and Geotechnique in Alexandria (Egypt): come and meet us at our stand!



THE LATEST SOFTWARE VERSIONS



Publications of 2009 first semester

- **Rades bridge drilled shafts designed and tested using Menard pressuremeter** (F. Schlosser, A. Guilloux, K. Zaghouni, P. Berthelot) International Foundation Congress and Equipment Exhibition - Expo IFCEE 09 - Orlando - March 2009
- **Projet Gautrain - La zone dolomitique** (S. Bounatirou, R. Storry, J.P. Viallon, F. Pignerol, T. Demonceaux, A. Guilloux, A. Bergère) Revue Travaux - February 2009



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