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terrasol
setec

New High-Speed Railway Line London/Birmingham


Photo credit: @DR

This project concerns the construction of a high-speed railway line linking London to Birmingham (phase 1), and then to Manchester and Leeds (phases 2a and 2b) in the north of England. Phase 1 of the project, currently under way, concerns a 200 km-section between London and Birmingham. It has been broken down into 7 civil engineering packages whose Design-Construction contracts have been awarded to various construction joint ventures. Two of these packages – packages C2 (North Portal Chiltern Tunnels to Brackley) and C3 (Brackley to South Portal of Long Itchington Wood Green Tunnel) – have been assigned to the Eiffage-Kier-Ferrovial-BAM (EKFB) joint-venture. The design of the civil engineering works for the C2 and C3 central packages is ensured by the Design Joint-Venture comprised of Arcadis-Setec-Cowi (ASC).

Packages C2 and C3 cross rural areas in the Midlands, covering a distance of 80 km. They include 15 viaducts, 3 cut-and-covers over a total length of more than 6 km, very high earthworks (embankments up to a height of 14 m and excavations down to a depth of 30 m), as well as a number of civil engineering works and highways.

The stratigraphy at the level of packages C2 and C3 mainly comprises the Cretaceous formations of the London sedimentary basin, and then the Jurassic formations of the East Midlands plateau, often covered with surface deposits. Due to the SSE normal dip of these formations and the erosion processes, the most recent formations are located at the southern end of the project and gradually get older to the north-west, going towards Birmingham.

The geotechnical issues identified along C2 and C3 are varied and, in particular, include risks of dissolution in the chalky formations, settlement under the embankments and, in conjunction, heave phenomena in the excavations in the clayey formations, as well as the presence of landslide shear surfaces that could be reactivated following the earthworks.

In addition to the ongoing ground investigation campaigns (boreholes, in-situ tests, geophysical tests, laboratory tests), it is also planned to carry out a variety of field trials:

- Preliminary fullscale static loading tests for the deep foundations to validate the construction methodologies in the different formations encountered along the project's alignment, as well as checking the expected behaviour;
- Trial embankments for the design of the mitigation measures aiming to limit the settlements of the earthworks both in the main section and for the viaduct transition zones;
- Trial cutting concerning the problems with heave of the clayey soils in the deep excavations;
- Trial embankments for reusing, treating and compacting the excavated materials as well as checking the expected behaviour with respect to Rayleigh waves.

The C2 and C3 Scheme Design studies (equivalent to a pre-design stage) were carried out from the autumn 2017 to the end of 2019. The Detailed Design studies have commenced at the beginning of 2020 on several structures identified as being critical such as certain viaducts, covered cuttings or the so-called "Calvert area" geographical zone where there is a strong interaction with the existing Network Rail lines.

For this Detailed Design phase, various setec subsidiaries (setec international, setec tpi, setec als, Terrasol, setec organisation), and our partners Cowi and Arcadis, are working together to carry out the studies (earthworks, alignment, civil engineering, geotechnics for the earthworks and structures, highways, drainage, landscaping and BIM) on a geographical section covering a distance of approximately 25 km in the C2 and C3 packages. In this multidisciplinary team, Terrasol is in charge of coordinating the geotechnical issues, and is more particularly involved in the geotechnical studies for the foundations of 4 viaducts and 21 overbridges. We also participate to the Optimisation team. Finally, we contribute with our partners Arcadis and Cowi in the Cat 3 checking of some of the engineering works of the C1 package.

B. Madinier and J. Habert

Editorial

The year 2020 has been very special for all of us. The "Covid crisis" led us to show agility individually and collectively, and to organize ourselves differently to continue to provide quality services to our customers, while respecting the health constraints and instructions. Our teams have been able to commit themselves and face this challenge, and I thank them warmly for this.

Our working methods have evolved considerably in a very short time: generalization of work from home during lockdown periods (while maintaining our activities on construction sites when possible), use of collaborative digital tools, organization of distance training by video: we have learned a lot and will be able to retain the best of it when we get back to "normal" life, which we hope will be the case within a few months.

More specifically, we have been able to maintain our overall level of activity in 2020: the projects mentioned in this issue illustrate some of our recent assignments. And our projects prospects for 2021 are promising (Grand Paris Express, London-Birmingham High Speed Line, Lyon-Turin rail project, EPR Sizewell, etc.).

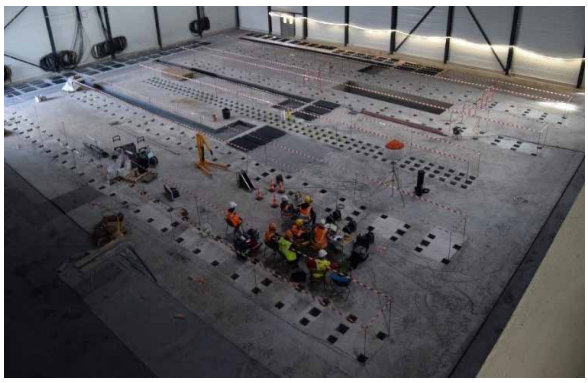
Our scientific developments are also continuing, with the launch of Scage, Foxta v4, and soon Talren v6, as well as our participation in the Asiri+ research project, and two ongoing PhD theses. In addition, we are more and more involved in reflections and actions to fight against climate change.

Wishing you a year 2021 as peaceful as possible,

Valérie Bernhardt

Foundations for a driverless vehicle simulator

Guyancourt, France



Terrasol recently worked for Groupe Renault on the construction project of a simulator for driverless vehicles at the Guyancourt Technocentre. Terrasol's assignment: qualify and validate the dynamic and vibratory response of the simulator foundations in relation to the performance criteria imposed by the manufacturer.

To comply with these criteria, the design moved towards a 32 m x 25 m x 1.50 m raft foundation solution resting on a group of 55 piles with a diameter of 1.0 m. The initial qualification phase was based on "hybrid" modelling using SASSI software, and considering the dynamic slab-pile-soil interaction effects. The dynamic behaviour of the soil was characterized using a Cross-Hole test campaign that was conducted beforehand.

Once the pile work had been completed and the slab had been cast, Terrasol supervised the vibration tests conducted on the slab using an unbalanced machine and a very high-precision acquisition system. The test results validated the dynamic performance of the slab with displacement and velocity amplitudes close to those estimated by the "theoretical" models. In particular, in-situ measurements confirmed that a significant group effect exists, resulting in a reduction in the overall stiffness by about 3 to 4 compared to an approach ignoring any pile interaction via the surrounding soil.

F. Cuira and J. Pérez-Herreros

Project management mission for the CDG Express project - Zone C

Paris area, France

The CDG Express project consists of creating a new 32-km direct line linking the Gare de l'Est railway station to Paris Charles de Gaulle airport. This link is divided into 7 zones from Paris (A/B) to Roissy (H). Terrasol is actively involved on zones A/B, C, D and F on behalf of SNCF and of several contracting companies, and was entrusted with numerous geotechnical design studies (G2), construction supervision missions (G4) or execution design studies (G3).

In the framework of the Zone C contract between the East and North rail networks, Terrasol is working with Setec on the global project management mission (MOE), bringing its geotechnical expertise to the different phases from design through to construction.

In the project phase, Terrasol has carried out all of the geotechnical studies for the project: analysis of the geotechnical data, design of the temporary and definitive shoring walls with contiguous piles for the cut and cover tunnel under the CAP 18 industrial zone, design of the deep foundations (piles and barrettes) for the future Porte de la Chapelle rail bridge, design of the ballast-free track, as well as recommendations for dealing with the risk of gypsum dissolution.

Photo credit: Cabinet d'architecture Alain SPIELMANN

After having contributed to the drafting of the tender documents and the assistance during tender assessment stage, Terrasol is participating in the construction management team. In charge of the Visa mission and supervision of construction activities, Terrasol has a team of three engineers involved including a resident engineer assigned to the site since March 2020. We are in particular responsible of supervising the execution of IRS injections, cavity filling works, soldier pile walls, contiguous pile walls and deep foundation piles. The site currently on hold is awaiting the finalisation of several administrative procedures to reschedule the relaunching of the works.

A. Abboud, H. Pillard and M.T. Hoang

CERN HL-LHC Point 1 project

Meyrin, Switzerland

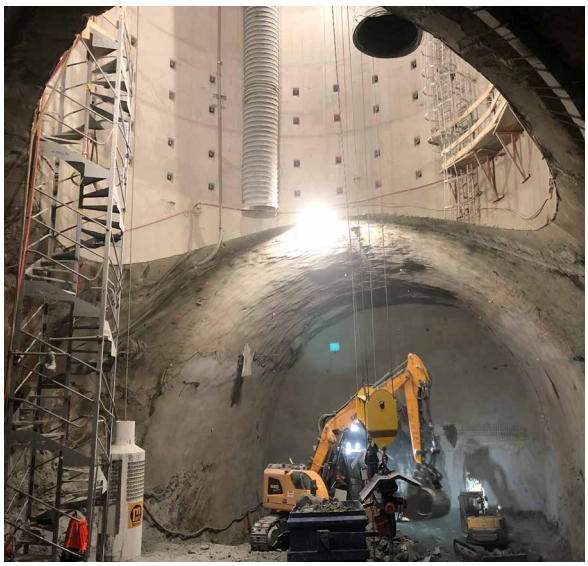


Photo credit: Setec

The High-Luminosity Large Hadron Collider (HL-LHC) project includes the construction of complex underground infrastructures. Setec, as the representative of the "ORIGIN" engineering joint venture, has steered the studies and construction works for the HL-LHC Point 1 project. These works consisted of constructing a new shaft, connected to a cavern which is in turn connected to new underground galleries. At the time of the design and construction studies, Terrasol carried out the design of the US/UW17 cavern, using a three-dimensional finite-element approach in order to take account of the interaction between the underground structures and the high anisotropy of the Red Molasse of the Lower Chattian.

On the basis of the geological field surveys and monitoring measurements during the works phase, it was possible during construction to optimise the support structure for the cavern considered in the design phase. On the basis of these new construction parameters, Terrasol subsequently carried out numerical back-analysis studies to adjust the soil geotechnical parameters to fit the on-site measurements (in particular convergences and stresses in the shotcrete).

These studies confirmed the better quality of the rock mass compared to the expected one and allowed to increase the stiffness of the rock mass and to decrease the stresses on the lining. The latter could thus be optimized in terms of geometry, thickness and reinforcements by means of a 3D calculation with statically indeterminate reactions method carried out by setec als.

J.P. Janin (with the participation of J. Voiron)

Reinforcement and restauration of the Saint-Cloud Great Waterfall

Saint-Cloud, France

The Centre des Monuments Nationaux has appointed Terrasol to take part in the reinforcement and restoration studies for the upper part of the Saint-Cloud Great Waterfall. Amongst the fountains embellishing the 460 hectares of the Saint-Cloud National Park, a listed historical monument, the Great Waterfall runs over a length of approximately 200 metres with a drop of about 20 metres following the natural slope of the hillside down to the Seine.

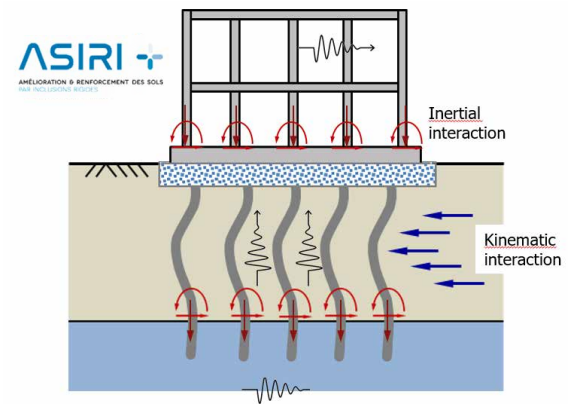
After its creation in 1664 and 1665, the current structure of the Saint-Cloud Great Waterfall has suffered from stability problems since the end of its construction, with reworking and restoration works extending from 1692 to 1892. In the geotechnical context of the Saint-Cloud hill which is known to be difficult, inclinometer instrumentation has been installed to measure any movements in the terrain, and has been completed by regular monitoring of piezometric levels. This will make it possible to carry out back-analysis calculations to adapt the reinforcement solutions that will be required.

The calculations will be performed with Talren v5 software, using the traditional slice method and the advanced slope stability analysis method (logarithmic spirals). The Terrasol's assignment started with the definition of the ground investigations, and went on with the preliminary and design studies. We will now provide technical assistance during the assessment of the contractors' tenders, and ensure supervision of the detailed design and of the works.

O. Payant

ASIRI+ National Research Project

Rigid inclusion ground improvements submitted to complex loadings



Terrasol is actively contributing to the ASIRI+ National Research Project launched in 2019, aiming to extend the technique of reinforcement by rigid inclusions for structures submitted to complex loading. This new national project, chaired by Bruno Simon (scientific expert at Terrasol), represents the continuation of the lessons learnt from the ASIRI national project (2005 – 2011) which mainly focussed on embankments, pavements and slabs submitted to static vertical loads, that were usually uniform.

The ASIRI+ project will include several lines of research with, in particular, full-scale tests being performed on foundations on rigid inclusions submitted to off-centre or inclined loading, which will offer Terrasol the opportunity to experimentally assess the MV3/MH3 models implemented in our Foxta software suite. ASIRI+ will also provide the opportunity to clarify the behaviour of soil masses reinforced with inclusions when they are submitted to cyclical (wind turbine foundations), dynamic (railway context) and seismic loadings.

Terrasol is particularly involved in the seismic aspects of this project with the funding of a PhD jointly supervised with the Institut Polytechnique de Paris (J.F. Semblat), aiming to contribute to a better understanding of the interaction mechanisms of inertial and kinematic origin that govern the seismic response of a soil mass reinforced by rigid inclusions. The purpose of this thesis is to develop a design tool combining simplicity and robustness (in the form of a dynamic macro-element) and providing an answer suited to the practical needs of the engineer.

F. Cuira and B. Simon

Project management of a flood storage site on the Seine River

La Bassée Valley, France

Photo credit: @DR

The La Bassée pilot site is the first of 9 flood storage sites on the Seine River, which will store 55 Mm³ of water and limit the impacts of floods. The design is based on the 1910 flood in the Paris area. This project is located upstream of the confluence of the Seine River and the Yonne River. The pilot site will allow to store 10 Mm³ on its own. It consists of 7.9 km of dykes, 2 to 3 m high, of a major pumping station of 40 m³/s capacity and of discharge structures enabling the site to be drained by gravity once the flood has passed. The project also includes various actions aimed at improving and enhancing the ecological context of the La Bassée valley.

In partnership with setec hydratec, Terrasol's assignment, within the framework of a comprehensive project management mission, involves carrying out all the geotechnical studies: design of the dykes, together with their connections to the pumping station and ancillary structures.

Terrasol's involvement included adapting the alignment to limit the impact on neighbouring areas (railway line, bridge pier, etc.), and optimising the ground investigations by cross-referencing geophysical and geotechnical surveys along the entire length of the alignment. Furthermore, through studying the stability of the dykes (bearing capacity, settlement, stability against major sliding and seepage through the embankment, foundation and abutments), judicious adjustments could be proposed for the construction measures to be planned along the alignment (slopes, berms, relief wells, cut-off walls, etc.).

Lastly, Terrasol assisted the Owner in seeking out embankment materials, by defining the requirements, potential procurement sources, temporary storage facilities and by providing assistance and support in discussions with other public stakeholders in the Paris area.

M. Brun and G. Chapron

Software department

Foxta v4

New major version

Here we present version 4 of our **Foxta** software suite dedicated to the calculation of shallow, deep, combined, rigid-inclusion and semi-deep foundations. This new version released in June 2020 offers a number of significant enhanced features:

- **TASPLAQ** now makes it easy to model rafts and slabs with complex shapes (triangular elements) and provides direct access to the mapping of the reaction coefficients that are useful for Soil-Structure Interaction analyses;
- **TASSELDO** includes a tool enabling the generation of 3D stratigraphic data starting from a network of borings, and settlement can be calculated using a linear or non-linear elastic model, or an oedometric model;
- **GROUPIE+** proposes an “advanced” mode making it possible to process groups of barrettes and to vary the soil conditions by family of foundations;
- **FONDSUP** now makes it possible to check shallow foundations using methods (PMT, CPT, c-phi) under static and seismic loads and provides access to the stiffness matrices required for Soil-Structure Interaction analyses;
- **PIECOEF+** includes an assisted input mode making it possible to generate p-y loading curves using PMT data, CPT data or elasticity parameters (G, v).

Lastly **Foxta** v4 also includes a new **SEMIPROF** module dedicated to the (non-linear) calculation of semi-deep foundations (shafts and mono-piles) under combined loading (V, T, M).

A demonstration version is available on our website and allows you to get an overwiew of the software capabilities. The software’s technical and user manuals are also available online.

Do not hesitate to contact us to find out more!

F. Cuira

Talren v6

New major version

Version 6 of our **Talren** software is currently being prepared and will be available for beta testing at the beginning of the year. This new version proposes enhanced features with respect to the treatment of reinforcements, hydraulic conditions (with integrated flow module) as well as seismic conditions. This new version also incorporates all the specificities related to the internal and mixed justification of soil-nailed walls in accordance with the new revision of the NF P 94 270 standard published in October 2020.

Y. Abboud and M. Huerta

Scage

New tool for the structural calculation of retaining walls

Scage is a new software dedicated to the verification and structural design of retaining walls. This first edition, developed initially in partnership with Atlas Fondations, covers the case of reinforced concrete retaining walls in accordance with Eurocode 2 and standard NF P 94 282. Here are some key features:

- Automatic generation of the **envelopes of the internal calculation effort diagrams** (from a preliminary calculation with **K-Réa** for example) with consideration of the "offset" rule;
- **Integrated reinforced concrete calculation in simple bending and compound bending**: treatment of partially and fully tensioned sections as well as in pure tension;
- Calculation of the **required cross-sections of longitudinal and transverse steel sections** from the results of the equilibrium calculation;
- Control of **cracking** in rectangular cross-sections;
- Independent **reinforced concrete calculator** to quickly check isolated sections separately from the considered project.

This new Terrasol software will be available from January 2021, within our software catalogue.

Do not hesitate to contact us to find out more!

C. Husson and M. Huerta

Publications

Please find our recent publications for 2020 on our website (i.e. more thant 20 papers), including our papers prepared for the « JNGG 2020 » in Lyon. This event had to be cancelled due to Covid crisis, but publications are available anyway.

Training courses

Our 2021 training catalogue will be published in the beginning of year 2021 and will be available on our website. Please check it to get the complete list of oncoming training sessions.

And please do not hesitate to contact us to organise on-demand in-house training sessions.

Head office

Immeuble Central Seine
42-52 quai de la Râpée
75583 Paris Cedex 12
France

Tel: +33 (0)1 82 51 52 00
Fax: +33 (0)1 82 51 52 99
Email: terrasol@setec.com

Rhône-Alpes office

Immeuble le Crystallin
191/193 cours Lafayette
69458 Lyon Cedex 06
France

Tel: +33 (0)4 27 85 49 35
Fax: +33 (0)4 27 85 49 36
Email: terrasol@setec.com

Representation in Morocco

Setec Maroc
3 rue Abou Hanifa
Agdal
Rabat - Morocco

Tel: +212 (661) 25 53 89
Fax: +212 (529) 03 64 00
Email: tarik.elmalki@setec.com

Terrasol Tunisia

2, rue Mustapha Abdessalem
El Menzeh
2037 Tunis
Tunisia

Tel: +276 71 23 63 14
Fax: +256 71 75 32 88
Email: info@terrasol.com.tn

Conception : Christine Remonnay