La Lettre

42 January 2025

terrasol

setec

ATMO for line 1 of the Abidjan metro

With a capacity of 540,000 passengers a day, Line 1 of the Abidjan Metro (L1MA) aims to improve mobility, the fluidity of urban traffic and the quality of life in this fast-growing agglomeration of 5 million inhabitants. This infrastructure, with a total length of 37 km, will cross the heart of the Abidjan urban region from north to south.

In order to reduce the impact of the infrastructure, which will be either gravel or embankment-based, 21 rail and road bridges, 34 pedestrian footbridges and, in the embankment areas, reinforced soil walls (VSoL) will be built to reduce the footprint in a very dense urban environment. To cross the Ebrié Lagoon between Plateau and Treichville, a 500 m viaduct is needed to double the Félix Houphouët Boigny road and rail bridge.

The **STAR** consortium (Groupement **SICMA** / **Colas Rail** / **Alstom** / **Keolis**) is responsible for design, construction, operation and maintenance of the L1MA. **Setec**, in a consortium with **EGIS** and **BNETD**, is providing project management assistance (ATMO) on behalf of the Ivorian government. Involved with the ATMO teams since the preliminary design phase of the project, **terrasol** carried out the geotechnical design review of the current and non-current engineering structures, stations, maintenance workshops and VSoLs. Since the beginning of the works in the autumn of 2023, **terrasol** has continued the document review mission on the implementation documents and provides support to the local ATMO teams by means of monthly on-site assignments aimed, in addition to providing its technical expertise, at facilitating technical exchanges with the construction consortium and the project owner.

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Crossing the Ebrié Lagoon proved to be a significant technical challenge. Located 2 m from the Félix Houphouët Boigny bridge, the metro viaduct is part of a complex geotechnical context consisting of a silt layer almost 40 m thick, resting on more or less dense, potentially heterogeneous sands, in which the 2 m diameter piles of the new structure are anchored, injected at the point.

Photo credit: © terrasol

From the preliminary design phase onwards, particular attention was paid to these foundations, both in terms of their impact on the existing structure (numerical modelling of interactions during construction and loading) and in terms of the reliability of the design. For the latter, in addition to the specific geotechnical investigations, a pile test using the Österberg cell was carried out on land near the southern pier of the structure.

In order to validate the design hypotheses and execution methods, the **STAR** consortium carried out an instrumented VSoL test backfill in the southern zone, in a context of loosely packed sands, to confirm the expected settlement speeds and amplitudes under the embankments of the structures and to qualify the contribution of reinforcement by rigid inclusions.

Over the past year, foundation works for the L1MA structures have made significant progress in several areas of the project:

- Work has begun on the deep foundations of different standard engineering structures;
- The rigid inclusions planned under the embankment of the Suwwd abutment on the Treichville side of the viaduct are under way;
- For the viaduct, the foundations for the land-based supports on the Treichville side were completed in the first half of the year, and the piles for the supports in the Ebrié lagoon were started in June.

B. Madinier & A. Beaussier

Editorial

The year 2024 marked an important step for **terrasol**, with a transition at the head of the company and the symbolic milestone of 100 employees. The new management team remains fully committed to preserving this unique geotechnical expertise, where many employees give their very best, while remaining true to the company's founding values of technical excellence, a culture of meeting the right needs and a spirit of transmission.

We continue to expand in strategic markets requiring high added-value geotechnical expertise. The transport infrastructure sector continues to play a leading role, with projects such as Lines 15 and 18 of the Grand Paris Express, the Lyon-Turin rail link, the Marseille Underground Crossing, as well as a number of major international projects such as the HS2 high-speed line (England) and the metros in Cairo (Egypt), Sao Paolo (Brazil) and Abidjan (Côte d'Ivoire). The year 2024 was also marked by an increase in our activity within the energy sector, with a commitment that will continue into 2025 on several EPR projects on behalf of EDF: Sizewell C in England, and the EPR2s at Penly, Gravelines and Bugey in France.

Our commitment to these projects goes hand in hand with our development and innovation strategy. The recent and forthcoming major improvements to our **Talren**, **Foxta** and **K-Réa** software and our **Orbow** web platform are one of the driving forces behind this. This strategy is also reflected in our contributions to the major events in the geotechnical community with a large presence, in 2024, at the JNGG (Poitiers), ISC7 (Barcelona) and ECSMGE (Lisbon), where **terrasol** presented no fewer than 26 articles and presentations.

Thanks to the collective efforts of all our teams and the renewed confidence of our clients, the 2024 activity ended with an excellent operational and financial performance. Our current order book means that we can look forward with confidence to 2025 and continue to invest in the digital transition, international expansion and sobriety of geotechnical structures. Our ambition is also to develop our expertise in the field of dykes and dams, offshore wind turbines and the rehabilitation of structures.

I would like to thank everyone at **terrasol** for their dedication and to all our clients and partners for their loyalty and trust.

Fahd Cuira

TELT, site supervision and visas

Modane, France

Starting in October 2021, the CO6/7 operational worksite between Saint Martin La Porte and Modane (73) is the largest section of the transalpine tunnel of the future Lyon-Turin railway line. With a total length of 23.1 km, this twin-tube section is being built by the **Vinci** / **Webuilt** consortium.

It includes:

- The construction of around 15 km of tunnels using traditional methods, notably crossing the squeezing terrains of the productive Houiller, the karstic limestones of the Dogger and the anhydrites of the Trias, which have a high swelling potential;
- Approximately 25 km of mechanised tunnelling, with 3 segmental tunnel boring machines operating simultaneously.

On this large-scale project, **terrasol** is subcontracting to the project management consortium **S2IP** / **SetecTPI** / **Systra** / **Italferr** et **Pini**. After collaborating on the PRO / ACT phase, including the design of the coal-face crossing, **terrasol** is in charge of geotechnical monitoring (face surveys, auscultations, risk management, etc.) and managing the VISA mission.

P. Antoniazzi, A. Bachelier, F. Bonfill & Q. Didier

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COREA GPE Line 15 East-South

Ile de France, France

Photo credit: © terrasol

Since January 2020, **terrasol**, in collaboration with the teams from **setec tpi**, has been assisting the consortium led by **Eiffage** with the design-build procedures for lines 15-East and 15-West of the Grand Paris Express automatic metro.

After carrying out preliminary geotechnical studies for all sections at the consultation stage, **terrasol** is now in charge of detailed geotechnical studies for the 18 km of the southern branch of line 15-East. This work package, which was awarded to the consortium in December 2023, is characterised by major issues relating to the risk of gypsum dissolution, a shallow water table, proximity to sensitive infrastructure networks (M5 metro, A86, RER-A, neighbouring stations, etc.), underground connections to structures on section 15-South already completed and in operation at the time of construction.

The services are being provided as part of the COREA consortium. They include geotechnical design (G2-AVP and G2-PRO) and supervision of execution (DET and VISA): definition of the geotechnical model for all project structures, geotechnical dimensioning of the TBM tunnel, geotechnical design and dimensioning of 5 stations, 2 spine structures and 1 connecting structure and mechanical dimensioning of the tunnel track support platform.

Preliminary works began in the summer of 2024 on 3 priority structures at Bobigny, Val-de-Fontenay and Champigny-sur-Marne, for which the first diaphragm wall panels are scheduled to be poured in early 2025. These structures will eventually enable the project's different tunnel boring machines to be brought into service.

J. Marlinge

The Grenouillère Aquatic centre

Antony, France

Alongside **setec bâtiment** and on behalf of the architectural firm **Dietmar Feichtinger Architectes** (DFA), **terrasol** is participating in the redevelopment of the Grenouillère aquatic centre in Antony, situated at the south-western end of the Parc de Sceaux.

The new aquatic centre will have three indoor pools. Outside, there will be two leisure pools and a wild river. An underground car park is also planned.

The major issue for the project was the requirement for a light-weight building with a deep underground structure, where load distribution leads to tension situations that require the use of deep foundations to anchor the building with respect to interstitial underpressures.

The studies began in 2019, with a G1-APS assignment. The G2-AVP and G2-PRO assignments followed in 2020 and 2021.

We are now in phase G4. The pile foundation has already been laid and the retaining walls of the car park are currently being completed.

S. Delattre Levis Leyser & M. Brun

Photo credit: © terrasol

The Baconnets Trench

Antony, France

terrasol is working with **SNCF Réseau** on a project to upgrade the Massy-Valenton line, the aim of which is to improve the flow of TGV and RER C trains south of Paris, improving their frequency and punctuality. The aim of the project in the western sector, from Massy-Verrières station to Les Baconnets station, is to eliminate TGV-TGV and TGV-RER traffic conflicts by creating a second track dedicated to TGVs. **terrasol** carried out the G2-PRO studies for this sector in 2023.

At present, the preparatory works (T3A) are being carried out by **Terélian** and **Botte Fondations** and include a 12 m high, two-storey studded wall and a berlinoise, both of which are temporary. The main works, awarded to **Bouygues TP** and **Solétanche-Bachy**, will start at the beginning of 2025 and will take advantage of the temporary structures to build the joint pile walls of the covered and open trenches of the future track, inserted between the RER B and RER C lines. **terrasol** is in charge of the G4 mission for all the works.

C. Girard, H. Pillard & J-F. Bruchon

Photo credit: © terrasol

ATP Cultural Centre at the Jardin d'Acclimatation

Paris, France

terrasol is assisting the prime contractor, **setec bâtiment**, on a project to transform the former National Museum of Popular Arts and Traditions, next to the Jardin d'Acclimatation in Paris, into the Maison LVMH - Arts, Talents, Patrimoine (ATP). All that remains of the old museum, which closed in 2005 and was built in 1969 on the site of the former Palmarium, is the metal framework of the central tower. The new building will maintain the shape and proportions of the old one, but will be wider and deeper, bringing the lowest point of the project below groundwater level.

These seemingly minor changes required major works: almost complete demolition of the old structure, underpinning of the tower structure retained by micropiles, a variety of retaining walls (anchored secant piles, nailed Berliner, Lutetian, studded walls, etc.), a general invert resistant to under-pressure, a temporary pumping and infiltration system.

Present since the feasibility phase in 2016, **terrasol** has performed the G2-AVP and G2-PRO design studies, exploring different development scenarios. **terrasol** followed the entire consultation phase with the contractors right through to the signing of the contracts, and is currently in charge of the G4 construction supervision mission from 2022 onwards, with the geotechnical works mainly performed by the **Franki** / **Keller** consortium, subcontracted by the general contractor **PETIT** (**Vinci Construction**).

Our engineers monitored the different geotechnical activities on site on a weekly basis, as well as measuring and analysing the instrumentation installed. Today, the geotechnical works are almost complete and the structure of the building is well advanced.

A. Abboud & H. Pillard

Photo credit: © terrasol

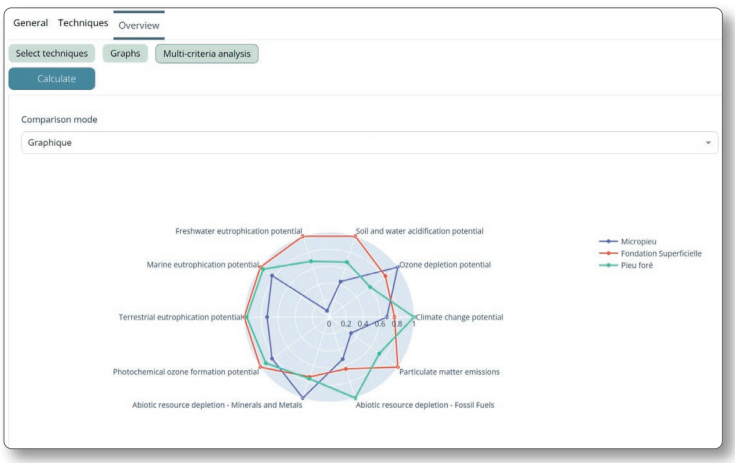
ecow v2.0

A significant update to the **Ecow** module, available on the **Orbow** collaborative platform developed by **terrasol**, was released for all users at the end of the year. Analysis of the environmental impact of geotechnical works is now more comprehensive, with the module now able to perform multi-criteria analyses, displaying 10 environmental impacts (including the global warming indicator, which was already calculated). The database has also been updated to comply with amendment A2 of standard NF EN 15804.

Another notable change is that for earthworks and earth movements, the module now calculates the environmental footprint based on the results of the TERCO2 research project (shared emissions monitoring data from several recent earthworks projects).

These changes reflect our commitment to remaining in line with the latest developments in standards, while incorporating the latest findings from the scientific community.

C. Bernuy



Softwares

Talren v6

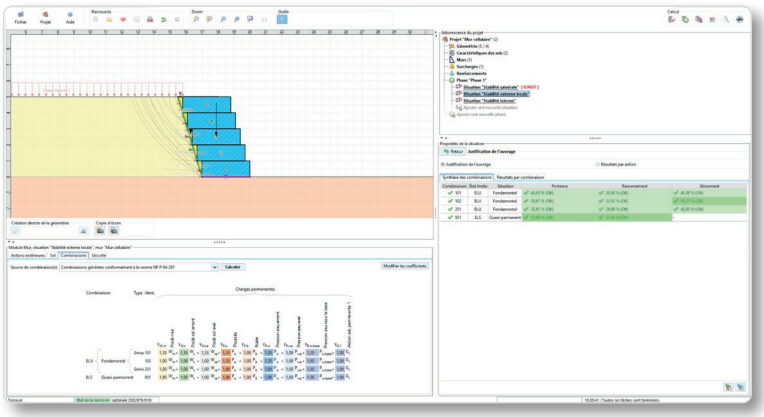
Cellular walls

The latest update to **Talren v6** includes an overhaul of internal balance analysis of cellular concrete walls in compliance with standard NF P 94-281 (Eurocode 7). This analysis complements the local external balance and overall external balance verifications already included.

- The major strength of the **Talren Wall** module is the assessment of limit thrust and abutment pressures using the kinematic method of calculation at failure, which means that it can cover configurations that cannot be dealt with using conventional analytical formulations (variable terrain, multiple loading, earthquake, variable inter-layers, taking account of reinforcements, etc.).
- By analysing the local external balance, it is possible to test the load-bearing, overturning and sliding mechanisms in the foundation soil using pressuremeter and penetrometer methods and drained and undrained shear parameters.
- A combination generator in compliance with Eurocode 0 has been integrated, allowing the coefficient values and safety levels to be manipulated.

The internal balance of cellular walls is analysed to verify overturning, sliding (shearing) and compression between blocks. Intermediate results are available to facilitate understanding. Finally, **Talren** provides access to the mobilisation rate of each resistance for each calculation combination, enabling the dimensioning verification to be identified.

C. Girard & M. Huerta



Foxta

K-Réa

Two major new versions coming soon

We are currently working on the next generation of **Foxta** and **K-Réa** software, aimed at considerably extending their scope of use:

- **Foxta**: the latest version will include all the main international standards, automated processing of loading combinations, and a significant upgrade of the **Groupie+** and **Tasplaq** modules, which will now enable the calculation of a flexible raft on piles interacting with soil mass. There will also be two new modules: **Fondsis** (seismic calculations) and **Tasiris** (rigid and flexible inclusions).
- **K-Réa 3D**: the next version will feature the calculation of a three-dimensional support structure. This will allow us to meet the requirements of our users when dealing with complex excavations, while maintaining a modelling approach adapted to the engineer's practical applications. This new version will also feature a 'hydraulic' module for estimating the flow forces to be taken into account in the design.

We will keep you informed when these new versions are available.

J. Pérez & F. Cuira

Training courses

The calendar for 2025 includes several inter-company training sessions. Here is the list of those scheduled for the first half of the year (in french).

17 & 18 march	**Foxta v4** - Dimensioning shallow and deep foundations
19 march	**K-Réa v5** - Sizing retaining walls
20 & 21 march	**Talren v6** - Stability analysis of geotechnical structures
24 march	**Orbow** - Introduction and discovery of the platform
23 june	Sizing rigid inclusions with **Foxta** workshop
24 june	Pressuremeter test interpretation workshop - Protocol & interpretation
25 june	Workshop Design of retaining walls with **Talren v6**
26 & 27 june	Dimensioning of geotechnical structures in accordance with Eurocodes 7 and 8

Don't hesitate to contact us to organise in-company training courses to suit your needs:
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