

High level of activity in Le Havre



For several years now, the city of Le Havre has been undergoing an image change and major transformation with a large number of city developments. HAROPA PORT | Le Havre is no exception to this momentum with several technically challenging infrastructure projects. The Terrasol teams are proud to be involved in two of them!

The first one concerns the third phase of the Port 2000 container terminal extension. It includes the construction of stations 11 and 12 with the development of 47 ha yard area, the construction of 700 m additional quay wall (1.5 m-thick anchored diaphragm wall) to accommodate container ships with a draught that can reach 17 m, a 111 m long wing-wall, and associated dredging works (works awarded to a consortium led by Soletanche Bachy).

The second one is located on the Joannes Couvert and Hermann du Pasquier quays. It involves a development project related to the installation of offshore wind farms, including the following ongoing works:

- two 200 m quays, the first called "Jack-up" dedicated to the berthing of jack-up rigs and the second one, called "Lo-Lo", dedicated to the import-export of various wind-turbine components (works awarded to a consortium led by Eiffage Génie Civil). The quays will be reinforced concrete structures placed on multiple type of supports: driven open-ended piles with a diameter of 1.63 m fitted with diaphragms, 2 walls of bored piles with a diameter of 0.9 m and a depth of 10 m anchored in a gravity wall built between 1905 and 1920 (25.5 m high and 14 m wide), and a wall of CFA piles with a diameter of 1.2 m and a depth of 27 m,
- redevelopment of a 12 ha yard for the storage and transport of certain components (consortium led by Eiffage),

- an infrastructure dedicated to Ro-Ro loading/unloading of 75 m long elements, awarded to NGE, including an anchored cofferdam 75 m long and 22.4 m wide comprising AZ38-700N and AZ40-700N sheet piles and reinforced concrete structures placed on CFA piles with a diameter of 1 to 1.2 m,
- cellular cofferdam structures about 100 m long and 30 m high to close-off an old wharf ("bassin aux pétroles"), awarded to Bouygues TPRF. This construction will make it possible to create a new platform using backfill from dredged materials.

For this cellular cofferdam structure, Terrasol has been working with Bouygues TPRF since the tender phase, through to the execution phase. For the other structures, Terrasol, with the support of the Setec Group, is providing HAROPA PORT | Le Havre with technical support as assistant to the project Owner. We are in charge of the concept design stages all the way to detailed design followed by tender assessment and execution design control for the "Jack-up", "Lo-Lo" and Hermann du Pasquier quay walls, whereas our mission for Port 2000 is limited to the execution design control with counter-models of the main quay wall structure as well as expertise on a number of specific items.

The design of all these structures - exceptional by their size and high design loads - required the greatest attention, hence the extent of the geotechnical investigations carried-out onshore and offshore and the justifications conducted as per the guidelines of the ROSA 2000 recommendations (taking into account a water level difference suited to the design conditions for each of the projects - tidal or floating docks, etc.) with advanced calculation methods. We can mention for example, several soil-structure interaction models for the quay walls, finite element modelling with Plaxis 3D for predicting

Editorial

The year 2021 was again a disrupted year due to the health situation and we would like first to sincerely thank our teams for having shown such a degree of agility regarding the organisation of (remote) work while remaining committed to provide services of the highest quality for our customers.

Thanks to everyone's mobilisation, we have seen strong growth (+10%) in our activity in 2021, combined with an unprecedented number of recruitments (16 talented newcomers over the year). It is now a team of 90 people who are at your disposal. And the perspectives for 2022 are just as promising.

Furthermore, besides our operational activity, whether in geotechnical engineering, software and training, we are going to invest heavily in the coming months and years in three strategic areas that are now essential: international business development, digital transition (with projects starting in 2022 in the area of web applications and data platforms), and climate change (with the definition of our own low-carbon strategy). These three areas are being steered by Antoine Abboud, Gilles Chapron and Charles Bernuy respectively.

Here we would like to express our gratitude to all our customers and partners for their renewed confidence, and offer you our best wishes for the year 2022, hoping that you will be able to make the most of it!

Valérie Bernhardt

the behaviour of the soils reinforced by rigid inclusions under heavy crane loads, Plaxis 2D modelling of the diaphragm wall for Port 2000, and 3D modelling for the connecting structures between the cellular cofferdams and existing quay walls.

Instrumentation-based monitoring of these structures is systematically carried out. This was completed by two static pile-load tests reaching a maximum load of 1,500 t to verify the bearing capacity of the driven piles, a plot test for injection and jet grouting tests to prevent any end-bearing capacity defects for these piles along the quay zones where a silty layer is identified, and a rigid inclusion test plot for the future heavy cranes operation area (integrated in the ASIRI+ National Research Program).

M. Brun and A. Abboud

Sarenne hydropower tunnel

Alpe d'Huez, France



Photo credit: @CNR - Béatrice Ailloud

CNR (Compagnie Nationale du Rhône) - holder since 2015 of the hydropower concession for the Sarenne river situated between Alpe d'Huez and Bourg d'Oisans - launched in spring 2021 the construction of a new high-head (735 m) hydroelectric facility. This new unit, with an installed capacity of 11 MW, will allow the annual production of 36 GWh and provide 16,000 local residents with energy from renewable resources.

The project consists of a water intake installed at an altitude of 1,456 m on the riverbed of the Sarenne and deviating the water flow to an upstream tunnel - 2,300 m long with a 20 % slope - excavated with a TBM. The tunnel comes out at the level of an intermediate platform located at an altitude of 1,000 m. After a short section through a cut, the forced conduit falls again into a shaft at 45° angle, executed by raise boring from an existing downstream gallery, to finally reach the hydroelectric plant at an altitude of 721 m.

The Spie Batignolles GC / Cogeis consortium secured Work Package 1 corresponding to the construction of the upstream tunnel with the TBM, the definitive disposal of the excavated material (~40,000 m³), and the installation of the forced conduit in the tunnel. The consortium chose Terrasol to carry-out the execution design geotechnical studies (G3 type mission), comprising in particular the elaboration of the following documents:

- Calculation note for permanent deposit of excavated materials on the mountain slopes,
- Calculation note for the retaining structures at the head of the upstream tunnel,
- Geotechnical assumptions notes and calculation notes for the supporting sections in the tunnel part excavated using conventional methods (TBM launching gallery) and in the mechanically excavated part.

The tunnel diameter is 4.13 m, and it is excavated going upwards. After a thin layer of limestone and dolomite, tunnelling is continued through massive metamorphic rocks (amphibolites and chlorite schists). Excavation of the launching gallery began in March 2021. The TBM was brought on-site and assembled in August, for the start of tunnelling at the beginning of September. Our mission will continue with the justification of the anchoring blocks of the forced conduit.

T. Rossi

Grand Paris Express - Clichy-Montfermeil metro station

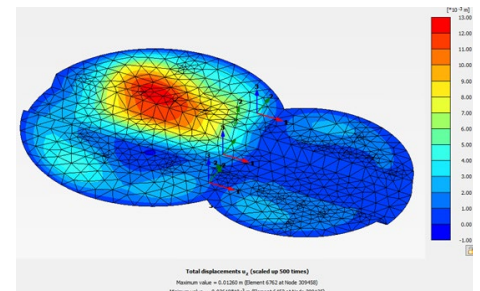
A new approach for taking into account the effects of swelling on underground structures

The swelling of clayey layers may lead to the generation of additional pressures on underground structures, accompanied by deferred uplifting of the foundation raft. So, taking the effects of swelling into account poses the question of the structural verification and functional compatibility of the structures to be built.

On the Grand Paris Express network, a large number of infrastructures cross or are anchored in over-consolidated clay horizons known to swell (plastic clay, green clay, Argenteuil marl). Various methods are used to simulate the effects of swelling on underground structures and lead to significantly different structures designs. The serviceability requirements for this new metro network impose severe limitations on the uplift control that may be incompatible with the conventional - often highly conservative - calculation methods.

In the framework of our mission as geotechnical assistant to Owner on line 16 for Société du Grand Paris, the contracting authority, a swelling simulation algorithm has been developed to estimate the uplift of Clichy-Montfermeil station's foundation raft which is located on Argenteuil marl. The algorithm exchanges with the Plaxis 3D software to impose a swelling deformation that depends on the stress state in the soil. The mechanism can be controlled in terms of vertical or average stress and the deformation can be imposed in an isotropic or anisotropic way.

Its application to Clichy-Montfermeil metro station has made it possible to refine the estimation of the raft displacements and help in the definition of the construction provisions.



M. Cahn, S. Burlon, N.H. Nguyen and O. Payant

Lekiny Bridge

Loyalty Islands, New Caledonia

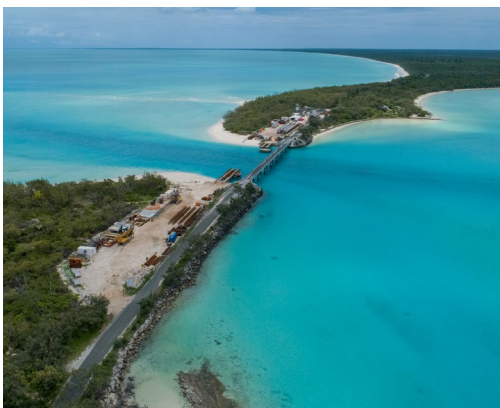


Photo credit: @ Gemoce (EyeFly Pacifique) - Loyalty Islands Province

Working for the consultancy company Gemoce, main designer of the structure, Terrasol is involved in the control of the execution design reports for the foundations of the Lekiny Bridge in Ouvéa, in the Loyalty Islands. This new bridge structure, comprising three spans (50 m, 80 m and 50 m), will cross the Mata One channel like the existing Mouli Bridge, built in 1982, and will make it possible to better meet the "environmental and safety challenges of its times" as highlighted by the Loyalty Islands Province.

In the framework of its design review and validation mission, Terrasol has carried out double-check calculations using counter models, making it possible to assess the robustness and reliability of the solution proposed by the consortium led by ARBE. Situated in a maritime setting and a specific geotechnical environment with fragile, porous layers of coral limestone subject to seismic forces, the bridge will be built on deep foundation piles and micropiles for the abutments and the piers whose construction technique has been specifically adapted.

The counter-calculations allowed to make the most of the latest developments on the Foxta v4 software enabling the modelling of a large number of piles under a general capping element, taking the piles inclination into account when necessary.

Y. Chen and S. Burlon

Consolidating the quarry under the “ZAC du Triangle de l’Echât”

Créteil, France

The “Triangle de l’Echât” development area between Maisons-Alfort and Créteil is a brownfield development project. The land allotment procedure is being conducted by the contracting authority, Grand Paris Aménagement, and aims to create a new landscaped district intended for housing and service activities. The site is located in an unfavourable geotechnical setting which in part explains why it has been overlooked to date despite its appealing location.

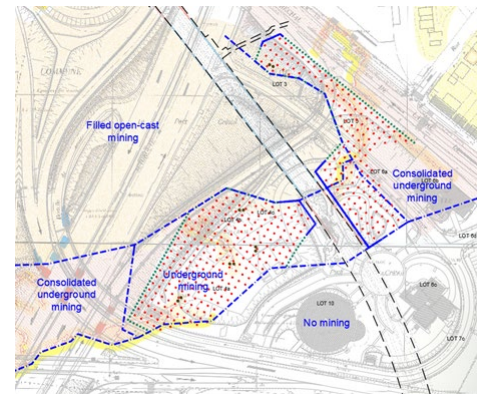
The area is undermined by old limestone quarries (“Calcaire grossier” geological layer). To the northwest, the layer is close to the surface and was subject to open-cast mining in the past, then filled with miscellaneous fill materials. In its central part, the limestone was mined underground, and this area has been partially mapped by IGC (Quarries General Inspectorate), revealing zones with unclear extensions. To the southeast, the layer runs deeper and passes below the level of the water table, which put an end to its exploitation. Lastly the metro line 8 cut-and-cover, a sensitive underground infrastructure, crosses the whole area.

Terrasol was chosen by Grand Paris Aménagement to ensure the complete project management for the quarry consolidation program:

- Diagnostic on the basis of the existing data (geotechnical surveys, IGC map),
- Preliminary design stage: justification of the consolidation techniques (single filling grouting), definition of the extension of the consolidation areas, recommendation regarding the investigation surveys and their monitoring, with the grid required by the IGC specifications,
- Detailed design stage: quantification / estimation of the works and definition of a phasing compatible with the development schedule, in coordination with IGC to ensure coherence between the consolidation works and the specific situation of each quarry area,
- Assistance during tender phase: production of the technical tender documents,
- Supervision of execution studies and site work.

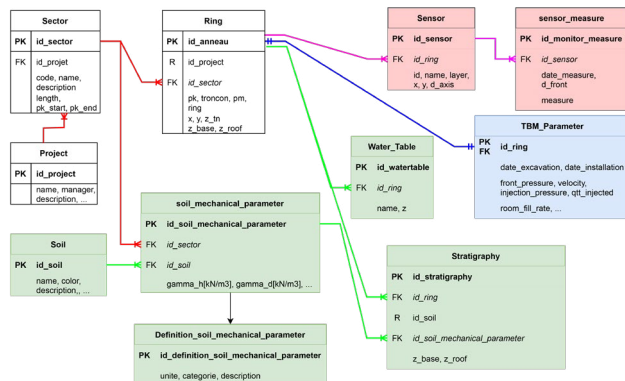
The injection works were carried out by Soleffi contracting company over an 8 months period in 2021, advancing between the different allotment zones, with a large number of inclined borings to avoid the existing utility lines, roads, the existing terrain variations and to minimise the impact on the local residents. In total, more than 700 borings were drilled, with 8,000 m³ of grout injected, to make a 11,000 m² area safe for development.

F. Binet



Data science on tunnel excavation data

CIFRE PhD / Terrasol - Ecole des Ponts ParisTech



Terrasol and Setec TPI are collaborating together with Ecole des Ponts ParisTech’s Navier Laboratory (Jean-Michel Pereira and Lina Guayacan) for a CIFRE PhD (Agreement on Industrial Training through Research) with the objective of reducing uncertainties on the behaviour of soils excavated by a TBM through the continuous analysis of the collected instrumentation data, with a real-case application on two sections of the Grand Paris Express metro. The first 18 months of the thesis work were devoted to extracting and filtering the massive instrumentation data consisting mainly of the TBM control parameters, and the soil behaviour data. These data are now feeding a PostgreSQL relational database that includes some 10,000 sensors and more than 50 million associated measurements, on a 15 km-length of tunnel.

In parallel with this essential extensive work, the thesis has progressed on the bibliographical part and on summarising the existing works linking Artificial Intelligence and tunnelling works (and more particularly the surface settlement predictions). As the database is now constituted, the second stage of the thesis

will be dedicated to testing the Soft Computing methods and analysing their performance. The goal is to be able to create a fast settlement assessment process using tunnel progress data, without complex recalibration steps, to improve the monitoring of the subsequent tunnelling sequences.

T. Richa and G. Chapron

Cocody Interchange

Abidjan, Ivory Coast

The Ivory Coast is a booming country and, consequently, its capital is developing modern, high-performance infrastructures. The particularity of Abidjan is that it is built around several lagoons, which imposes important bridges for crossing them.

After having worked with the Setec group on the design and construction management of some iconic constructions (4th Abidjan bridge, Houphouët Boigny bridge), Terrasol is currently performing the execution design for ground reinforcement on another exceptional project: the Cocody interchange project. This project includes a set of structures comprising a main cable-stayed bridge with a span of 200 m supported by a single off-center pylon, ancillary structures for the interchanges, and access roads in fill sections. The works are entrusted to China Road and Bridge Corporation (CRBC) construction company under the Project Management of Pierre Fakhoury/Arcadis, and with Egis for the external control mission.



Photo credit: @Pierre Fakhoury architecte

The geotechnical context of the Abidjan lagoons, consisting of great thicknesses of loose sand, implies that ground reinforcements (rigid inclusions) are required to control the settlement of the backfill embankments. CRBC chose Terrasol for the design calculations of the inclusions owing to our knowledge of the local geology and our expertise in the design of this type of soil reinforcement (thanks, in particular, to our Foxta software, fully adapted for Rigid Inclusions design).

J. Drivet

Software department

Talren v6.1

New features

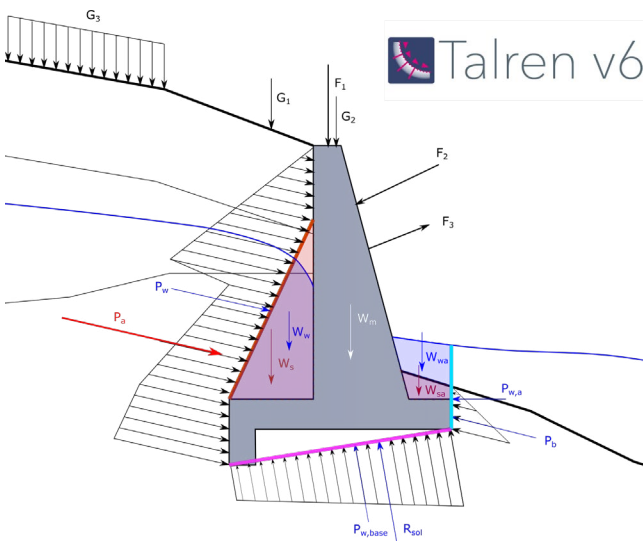
Eagerly awaited by our users, the forthcoming update of Talren will propose two new modules:

- “Active/passive earth pressures” module for the automatic calculation of the active/passive earth pressure diagrams for any soil stratigraphy,
- “Wall” module for calculating the stability - internal and external - of one or more retaining walls.

The “Active/passive earth pressures” module uses the capacities of the kinematic method (yield design method) to automatically determine the active and passive limit pressure diagrams, along a vertical or sloped plane placed anywhere in the Talren model. The active/passive earth pressure diagrams thus calculated take into account the effects of surcharges, seismic effects and the resisting contribution of reinforcement elements. It will be possible to use these diagrams as input data for the design of a retaining wall (using K-Réa v4) or for the design of a gravity wall (using the new “Wall” module in Talren v6).

The new “Wall” module covers the problems of the global, local external and internal stability of gravity walls, L- or T-shaped walls with or without a shear key, cellular walls of gabion or reinforced concrete elements, or masonry walls. The justification of the wall is done in compliance with French standard NF P 94-281. The module includes an ULS/SLS combinations generator in line with Eurocode 0 or according to a user-defined system.

Y. Abboud and M. Huerta



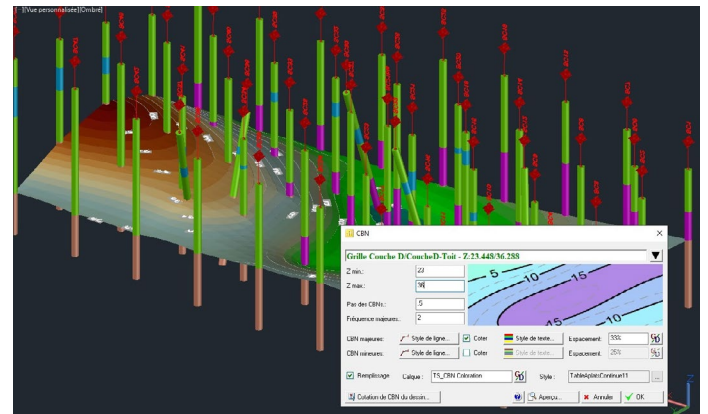
Talren v6

Straticad v3

Major version upgrade

Straticad, our geotechnical data drafting tool with 2D/3D representation, continues to evolve to meet the needs identified during its everyday use. Starting from the same database used to create borehole logs, Straticad v3 will make it possible to filter these data, apply a kriging interpolation method and return contour line mapping for the top and bottom levels, or the thickness, of a soil layer, with the possibility of creating 3D surface objects for the purpose of generating volumes. Straticad v3 will also propose the automatic drawing of an elevation profile for multiple soil layers. This new Straticad version will be available in early 2022.

M. Anic-Antic

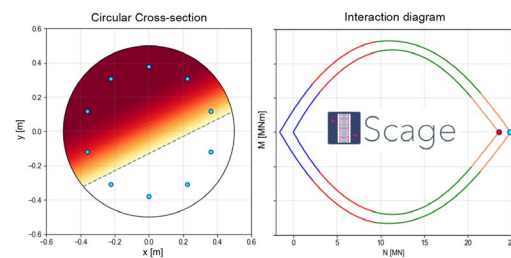


Scage v2

New features

The next update of Scage (2nd trimestre 2022) will integrate the processing of reinforced concrete piles (circular cross-section) and barrettes (rectangular cross-section) for simple, compound and deviated bending. The verification of the internal equilibrium is performed on the basis of interaction diagrams at ULS and SLS conditions for each reinforcement section verified.

M. Huerta



Publications



Please find our recent publications on our website, including our papers prepared for the AFTES Congress 2021.

Training courses



Our 2022 training catalogue is 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.

formations.terrasol@setec.com

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) 16 20 78

Fax: +212 (537) 77 48 41

Email: ahmed.skalisenhaji@setec.com

Terrasol Tunisia

2, rue Mustapha Abdesslem
El Menzeh
2037 Tunis
Tunisia

Tel: +276 71 23 63 14

Fax: +256 71 75 32 88

Email: info@terrasol.com.tn