Geosynthetics Conference
Feb. 10-13, 2019 | Houston, TX USA

Innovative Soil Reinforcement Solution with Geotextile Geocells – An Overview

Mathilde Riot, Technical Manager,[1] Maxime Soude, Geosynthetics Product Manager,[2] and Stephan Fourmont, Business Development Manager

[1]AFITEX, 13,15 Rue Louis Blériot, 28300 Champhol, France ; e-mail: mathilde.riot@afitex.com
[2]SOL SOLUTION, ZA des Portes de Riom Nord, 23 avenue Georges Gershwin BP 178, 63204 Riom, France, FRANCE ; e-mail: maxime.soude@sol-solution.com
[3]AFITEX TEXEL, 1300, 2e Rue, Parc Industriel, Sainte-Marie (QC) Canada G6E 1G8; e-mail: sfourmont@draintube.net

ABSTRACT

One of the important issues in the construction of geosynthetic reinforced walls is the supply of natural backfill materials with the required properties needed for the stability of the wall. M3S geotextile geocells make it possible, in addition to the construction of reinforced structures with complex shapes, to reuse the soil material excavated on site to build the wall, including those with very poor geotechnical characteristics. For specific sustainment wall case, choosing an adapted soil depends on its compatibility with used geosynthetics and most often on its mechanical parameters (Volumic weight, internal friction angle and cohesive strength) and its compacting ability according GTR manual recommendations. All that parameters come from Standardized Geotechnical Missions (NF P 94-500). Deduced from direct measures or correlations, parameters values are designed and controlled from the start to the end of works. This publication presents a project in a wind farm in France, realized with the M3S cellular system and its mechanical and functional characteristics. It also gives the main design steps to consider, the advantages of this solution and the limits of the system.

INTRODUCTION

The study of a reinforced earth structure designed through the construction of a wind farm in Zondrange-Morlange, France highlights the constraints of an ambitious project and shows how a retaining structure made with geotextile geocells can adapt itself to this type of constraints. Structures reinforced with geotextiles consist in increasing the mechanical performance of a soil (mainly shear resistance) by associating it with flexible inclusions such as geotextiles, similar to the steel bars of reinforced concrete. The design of such structures needs a strong geotechnical knowledge as well as a background on geosynthetics. Unlike geosynthetics that exhibit stable properties due to extensive quality controls during the manufacturing process, soil matrix will vary from a site to another and even from the beginning to the end of the excavation work. This is especially true since design engineers try to reuse in-situ soil to build the reinforced structures, it influences the soil stability itself and also the soil-geosynthetic interface.

Consequently, these difficulties on soil characterization and control have a very strong impact on the justification of stability of the structures. Indeed, from the design (NF P 94-270) to the execution of works (NF EN 14475), taking into account the influence of the soil material in contact with the geotextile is omnipresent. The design, as presented in the calculation standards, is based on rheological models for each material and involves commonly encountered mechanical parameters which are the density γ, the internal friction angle φ and the cohesion c. If in theory, geotechnical engineers have a lot of information and elements for their design, the practice often confronts realities of project modifications, significant heterogeneity of materials or purely economic constraints resulting in light characterizations of materials. Sometimes these materials are simply not suitable for the work that is planned to be done.

In this case study, the predominant parameter was to adapt the geosynthetic to the material in place, which led to the implementation of geotextile geocells. The first part describes the context of the project, then the geotextile geocells system is presented. Finally, the main design steps are described and the limit of this solution is also considered.

CONTEXT OF THE PROJECT

Situation. The wind farm of Zondrange-Morlange, in the North of France is provided for the construction of ten wind turbines and the construction of access roads for the transportation of wind turbines (Figure 1).

Figure 1. Situation of the two platforms and the access road before work.

Steep slopes, added to the erosion effect, led to instability of the structure and disorders. Gullies along the slopes and even a start of landslide were visible on site (Figure 2).

Figure 2. Erosion on the slope and beginning of landslide.

Constraints of the project. Platforms are isolated and difficult to access making it very expensive to bring fill material on site. The machinery traffic on the site is to be limited because of the circulation of the local farming activities. There was also a large stock of gravely-clay material onsite to evacuate.

AN INNOVATIVE GEOSYNTHETIC GEOCELL

The different types of geosynthetics for soil reinforcement. There are three main types of Mechanically Stabilized Earth (MSE) retaining structures, all made of pre-fabricated wall facing elements and a soil mass that is reinforced with geosynthetic materials. Uni-directional and bi-directional reinforcement geosynthetic systems operate using the friction and/or interlock between the geosynthetics and the granular soil and they require anchoring. Three-dimensional systems as geosynthetic geocells operate with containment and do not require anchoring or specific fill material.

Three-dimensional reinforcement. The M3S geotextile geocell system is a non-woven needle punched alveolar reinforcement made in polyester (Figure 3). The cells are 630 mm (25 in.) diagonal and 250 or 350 mm (10 or 13-4/5 in.) high. The bonds between the cells are made by seams on two bands and geotextile outgrowths is using as a hook for the facing surface.

Advantages of the geotextile geocells system for this project. The geotextile geocells system offers numerous advantages on the project like the low storage space needed for supplies (Figure 4), the implementation without truck entries and exits, the valorization of the natural resources with the complete reuse of the excavated material and the overall cost savings. Even the gravely-clay material is suitable for the retaining structure by geotextile geocells M3S. The reduction of the truck traffic also permits to reduce the Greenhouse gas (GHG) emissions. Last but not least, this innovative system allows to set up a very large choice of facing in front of the structure.

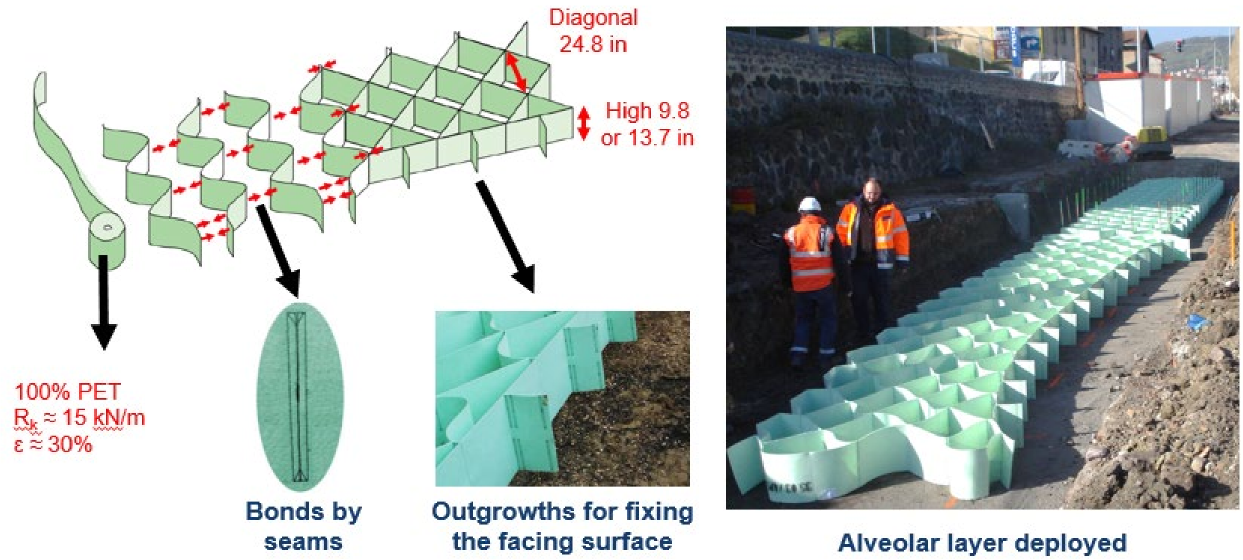

Figure 3. Details of the Geosynthetic geocells M3S.

Figure 4. Storage area for a 200 m (656 ft.) long and 4 m (13 ft.) high retaining structure.

On-Site Construction Steps. The main steps in the construction of the retaining structure are deployment and picketing of the first layer of the M3S geocells, backfilling and compaction then the next geocell layer is deployed etc. At the end is the installation of the facing structure. The facing system can be installed after expected deformations and stabilizations (if any) because the siding is dissociated from the retaining structure.

GENERAL PHASING OF WORKS AND DESIGN STEPS TO CONSIDER

Realization of the toe. First, the retaining structure by geosynthetic geocells starts with the realization of the toe. Figure 5 describes the different step of realization.

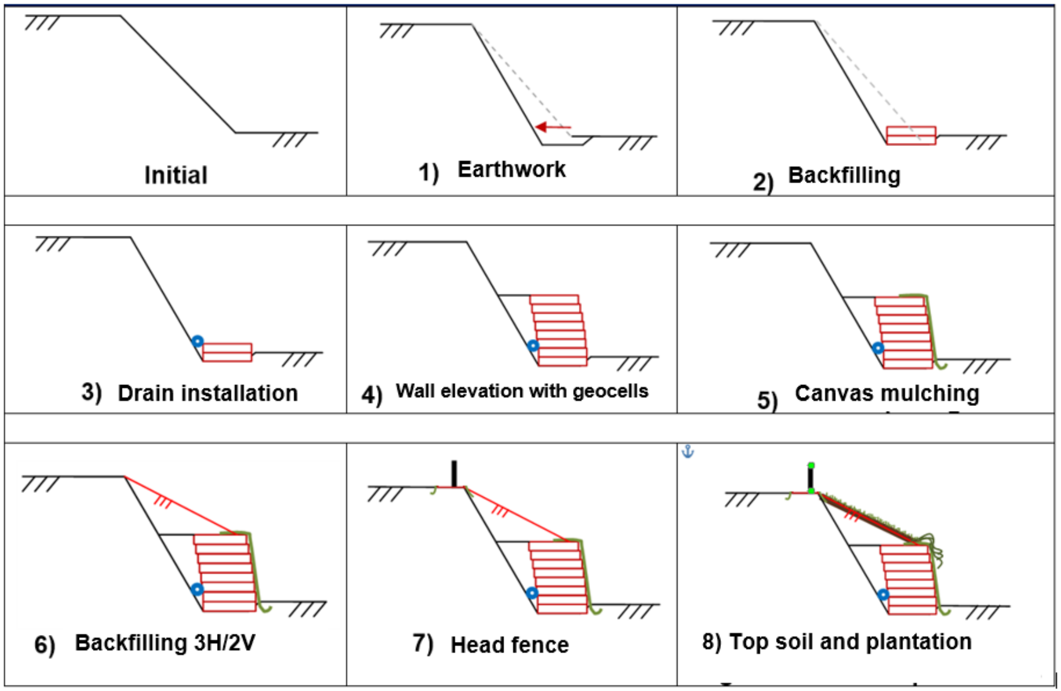

Figure 5. General phasing of reinforcement work.

Studies and preliminary recognitions. Two preliminary studies helped to design the structure. The first required a geotechnical study with an excavator and the installation of a pressure meter at about 50 m (164 ft.) of the future reinforced structure. The second required laboratory analysis and enabled to control the input data. Then Panda® analysis was carried out at the bottom of the excavation to control the compaction of the material that will be used to build the wall. Table 1 presents the technical model selected for the project.

Table 1. Technical model selected.

TECHNICAL MODEL	
Material	**Characteristics**
Sablo marly clay GTR A2m	All the elevations including work Material exercising the pushes Low carrying capacity
0/80 mm soil	Backfilling material
Limestone soil	About 11 in. deep
Hydraulic groundwater	Presence of groundwater infiltrations No risk for the project.
Seismic conditions	Very low risk

Normative context and stability assessment. The preliminary study shall meet the current Standards: Eurocode 7 and NF P 94-270. Limit state design requires the structure to satisfy two principal criteria: the ultimate limit state (ULS) and the service ability limit state (SLS) (Figure 6).

On that specific project, there was no limit value for the settlement of the structure due to the agricultural parcel around the wind farm.

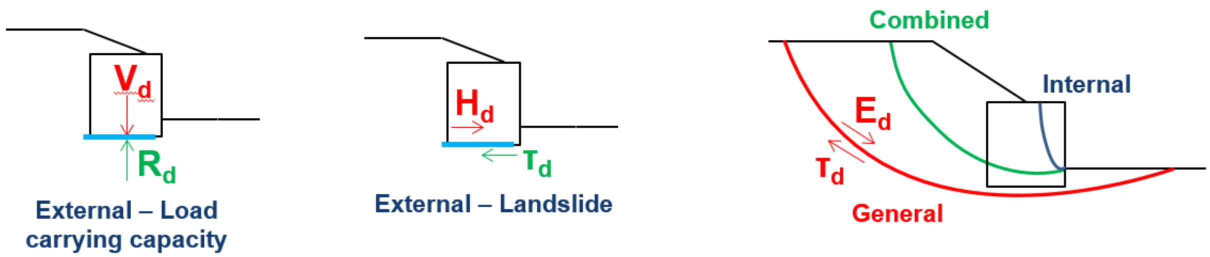

Figure 6. Verification of the ultimate service states.

Modeling. The modeling is achieved using TALREN5® software. Several stability analyses are then conducted on the overall structure (Figures 7 and 8).

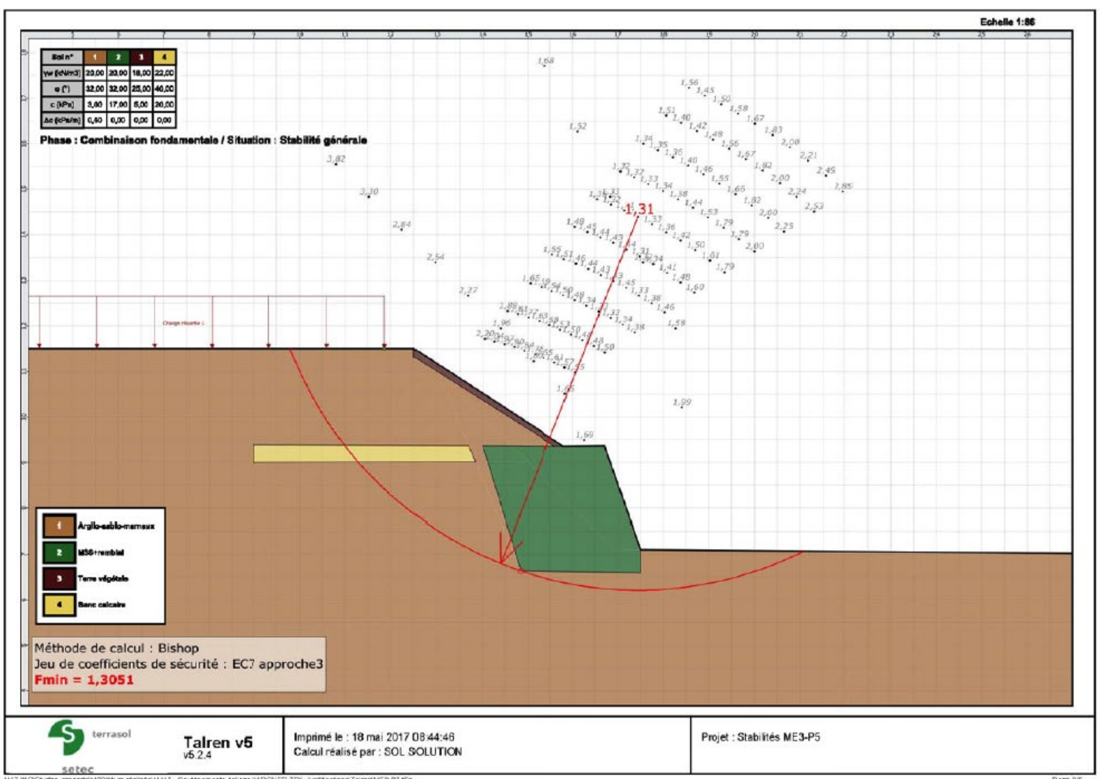

Figure 7. General stability assessment using TALREN5.

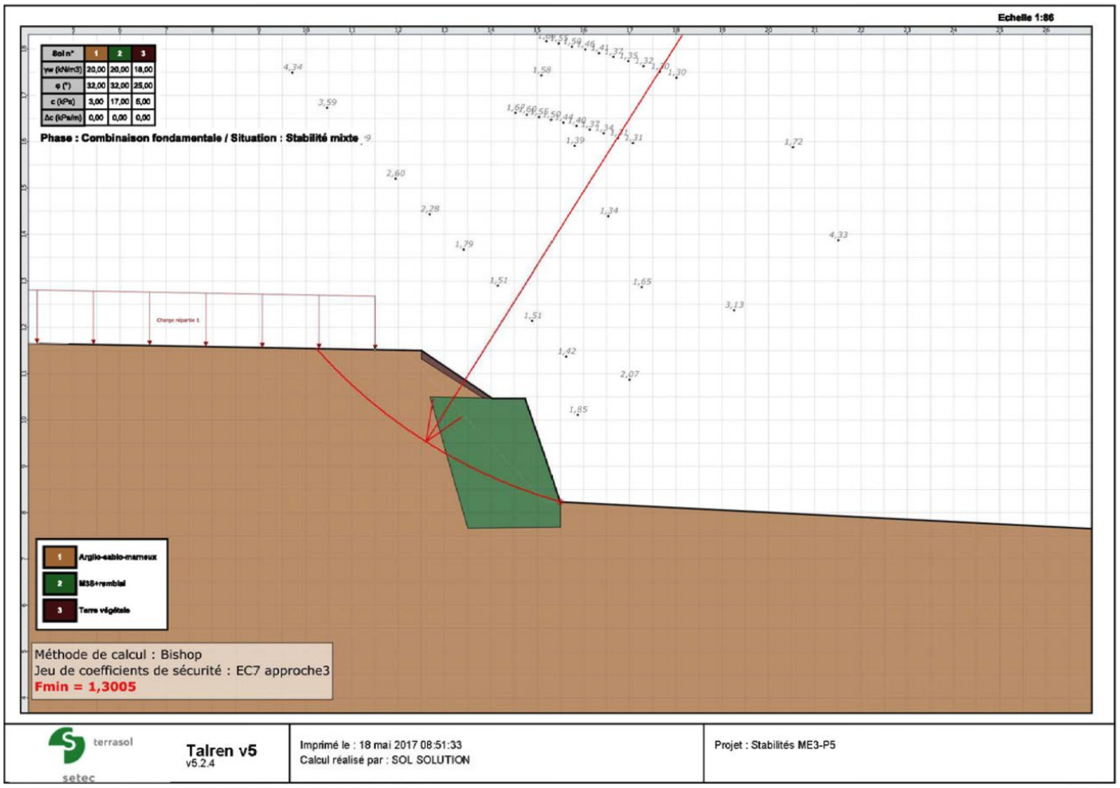

Figure 8. Combined stability assessment using TARLEN5.

CONSTRUCTION PROCESS

Preparation of the subgrade and geocells deployment. The subgrade is first excavated at the required level (Figure 9) then compacted. The compaction is controlled using PANDA® penetrometer.

Figure 9. Excavation of the subgrade of the work.

The M3S geocells are temporarily maintained open with metal pins during deployment (Figure 10). Afterward, these pins are removed.

Figure 10. Geocells deployment.

Backfilling and compaction. Backfilling is made with the onsite material using a digger. The compaction is achieved with a manual compactor (Figure 11).

Figure 11. Backfilling and compaction.

These operations are repeated to raise the reinforcing structure (Figures 12).

Figures 12. Elevation of the retaining structure.

Implementation of the top of the structure and the facing system. The top of the structure is backfilled with top soil and the facing is placed in front of the geocells system. For this project it's a simple geovegetation mat with seeding (Figure 13).

Figures 13. Finalization of the retaining structure.

LIMITS OF THE CONCEPT

There are no real technical limitations to retaining structures with geotextile geocells. Like every reinforced structure, it must be properly design in regard with its stability. The main limitations are economical. That type of solution will be cost effective for reinforced structures over 5 m (15 ft.) long and 1.5 m (5 ft.) high. Gabions and rock rip rap will be more competitive for small projects. The geotextile geocells system is optimal for retaining structures 3 to 6 m (10 to 20 ft.) high and 100 to 200 m^2 (1100 to 2200 sqft) of facing.

CONCLUSION

Among the constituents of a soil structure reinforced by geosynthetics, the soil material represents a very important mechanical data. The current parameters that define it (voluminal weight γ, angle of friction φ, cohesion c) are used in all the stability designs of a reinforced structure. It should be remembered that in most cases, it is the in-situ soil (inside or behind the structure), that leads to the sizing of the reinforcing geosynthetics and not the reverse. Among all the parameters to be defined, the predominant influence of the angle of friction in the computation of the thrusts (main stress) and in the calculation of the shear resistances (main resistant force) makes it the most critical parameter to define.

Despite of numerous constraints like the work area, the site accessibility and the bad characteristics of the soil material on site, the wind farm retaining structure has been successfully achieved in respect with expected time and costs. The geosynthetic geocells system adapted itself to all these constraints because it permits to use the onsite excavated material.

The installation of the system is fast and does not require heavy machinery. Moreover, the reinforced structures with geotextile geocells system resist to high differential settlements and are compatible with very bad bearing capacity or water-saturated soil.

REFERENCES

Burlon, S. and Co. (2017). *Calcul des ouvrages géotechniques selon l'Eurocode 7,* DUNOD, Malakoff, France.

NF EN 1997 (2007) – Eurocode 7 : Calcul géotechnique – Partie 1 : Règles générales et Partie 2 : Reconnaissance des terrains et essais. *AFNOR*, France.

NF EN 14475 (2007) – Exécution de travaux géotechniques spéciaux – Remblais renforcés. *AFNOR*, France.

NF P 94-105 (2012) – Sols : Reconnaissance et essais – Contrôle de la qualité du compactage – Méthode au pénétromètre dynamique à énergie variable – Principe et méthode d'étalonnage du pénétromètre – Exploitations des résultats – Interprétation. *AFNOR*, France.

NF P 94-270. Calcul géotechnique - Ouvrages de soutènement - Remblais renforcés et massifs en sol cloué. *AFNOR,* France.

Racana, N. (2002). *Etude du comportement mécanique d'un massif en sol renforce par géotextile cellulaire,* Université Blaise Pascal – Clermont II, Aubière, France.

Soude, M. (2014). *Eléments d'information sur les prestations SOL SOLUTION pour la construction d'ouvrages de soutènement en sol renforcé M3S®,* Riom, France.