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REINFORCED SOIL RETAINING STRUCTURES – DOMAINS OF USAGE

BY

OANA-ELENA COLȚ*

"Gheorghe Asachi" Technical University of Iaşi
Faculty of Civil Engineering and Building Services

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Abstract. Reinforced soil is a composite material (soil filling – reinforcement) used for both slope stabilization and retaining structures. The advantages created by the use of these technical solutions – both the economic and technical point of view – regarding the adaptability to the final requirements of the construction work compared with the classical solution, led to an expansion of the use of reinforced soil retaining structures in various fields of construction works (cone quarters and access ramps for bridges, embankments for railways and roads, retaining walls related to transport infrastructure, dams, protective retaining structures).

Key words: reinforced soil; reinforced soil retaining wall; retaining structure; reinforced soil structures; road embankments; quarter cone.

1. Reinforced Soil – Generalities

Above all reinforced soil is a composite material consisting in the association of soil and reinforcement, the latter made of metallic materials (galvanized or stainless steel in strips, grids, bars) or geosynthetics (geotextiles, geogrids or geocomposite for reinforcement) placed horizontally, and with the

*Corresponding author: *e-mail*: oanacolt@gmail.com

ability to take high tensile forces that appear in the earth, giving the active pressure behind the structure. As in the reinforced concrete, the reinforcement is used to improve the mechanical properties of the base material, so the soil will be reinforced only on the direction that is most tense.

Starting from the basic idea of fitting the reinforcement in the soil to increase its shear resistance, along the time various construction technologies were used in order to build reinforced soil retaining structures. The main differences between these technologies are related to the use of different materials for the facing and the reinforcements, to the construction method, and of course to their use in various fields of construction (Colț, 2014).

2. Reinforced Soil Retaining Structures in Constructions

The GP 063-2006 (Guide on the design of reinforced soil structures with geosynthetic and metal materials) presents the use of reinforced soil by the field of activity, referring to (GP093, 2006):

a) reinforced soil works on bridges (bridge abutment, abutment combined with pile foundation, abutment slope, reinforced embankment for viaducts);

b) reinforced soil works related to road infrastructure (embankments of reinforced soil supporting roads or highways, reinforced soil retaining structures);

c) reinforced soil used to build railways (embankments supporting the railways, reinforced soil retaining structures);

d) reinforced soil used in hydraulic structures (piers, dams of local materials, artificial islands and earth fill geocelles, retaining structures for banks; enlargements structures for the existing dams).

In addition to these types of reinforced soil construction works presented in Romanian guide GP 063-2006, reinforced soil could be use also for other types of construction structures in various fields:

a) temporary retaining structures necessary for reconstruction projects in infrastructure – giving the relatively low costs compared with other solutions;

b) dams of reinforced soil used for water and residues retention structures surrounding the reservoirs of oil or natural gas;

c) reinforced soil slopes for in construction of landfills;

d) acoustic walls and rock fall protection;

e) retaining structures for limiting the pressure on the foundation soil used in civil engineering.

In France, where these composite material was "rediscovered" and patented in 1963 by Henri Vidal, reinforced soil is successfully used today in all areas of construction works. The technologies used in France to build reinforced

soil construction works are various (Terre Armeé / Reinforced Earth, Textomur, Tervoile, Pneusol, etc.), and these technologies are primarily adapted the final requirements of the construction work (Colţ, 2014; Colţ, 2007).

3. The Use of Reinforced Soil Solution in France

The technical solution most frequently used in France to resolve the problems like stability of slopes, falling stones on the slopes, the construction of embankments for railways and road, the access ramps for bridges, etc. is the reinforced soil.

These types of works are encounter especially in mountainous regions, such as region of Rhone - Alpes (Savoie, Haute Savoie, and Isere). The versatility of using this composite material can be highlighted by a series of works constructed in this region in autumn of 2006.

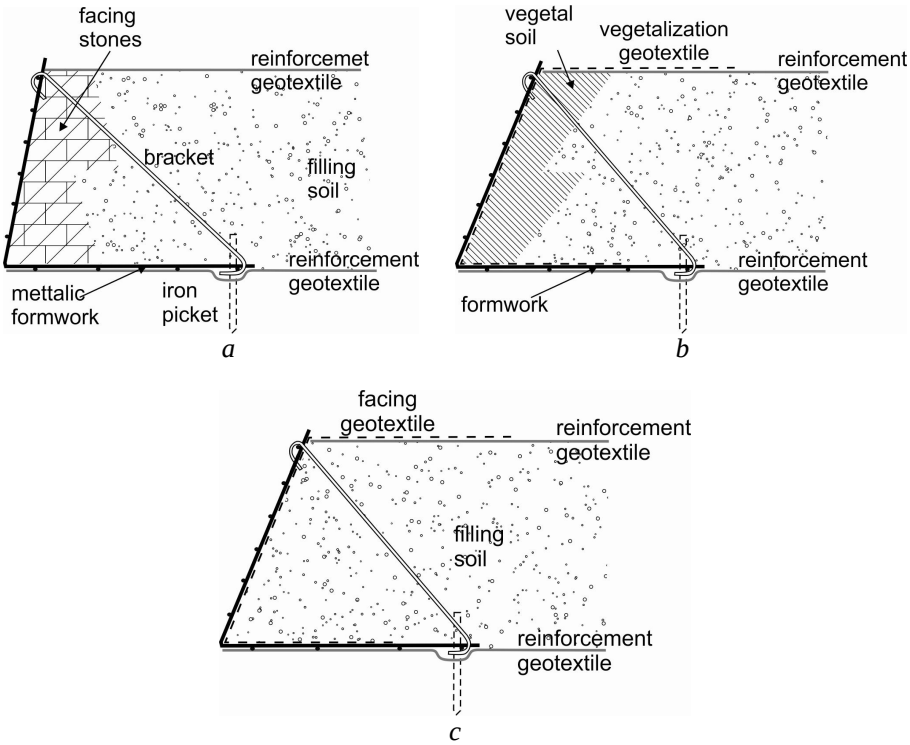


Fig. 1 – Types of Textomur: *a* – mineral facing, *b* – vegetal facing, *c* – neutral facing.

The technology used in these examples is Textomur. The Textomur system (Fig. 1) consists in facing elements of prefabricated formwork made of metal welded steel (galvanized or not) with geogrid or geotextile reinforcement

placed horizontally at a distance imposed by the size of the formwork, and between the reinforcements is the compacted fill: cohesive or uncohesive soil. Depending the type of facing, Textomur system can be constructed with a: mineral facing (Fig. 1 *a*), vegetal facing (Fig. 1 *b*) or a neutral facing (Fig. 1 *c*) (Colț, 2014; Colț, 2007).

An adaptation of this system which takes in account the final requirements of the work, used especially where it necessary to mitigate the impact energy, is the Pneutex system that replaces the facing made of metal formwork with a facing made of used tires, like in Pneusol system.

3.1. Reinforced Soil for Bridge Works – Quarter Cone and Access Ramps

As an example of the use of reinforced soil in bridges works is presented the construction of the access ramps and cone quarters of a passage from the RN90 road project, deviation Centron, France, passage that will serve a mountain road (Fig. 2) (Colț, 2014; Colț, 2013).

As construction system for this work was used Pneutex system – reinforced soil with geotextile reinforcements and the facing made of used tires.

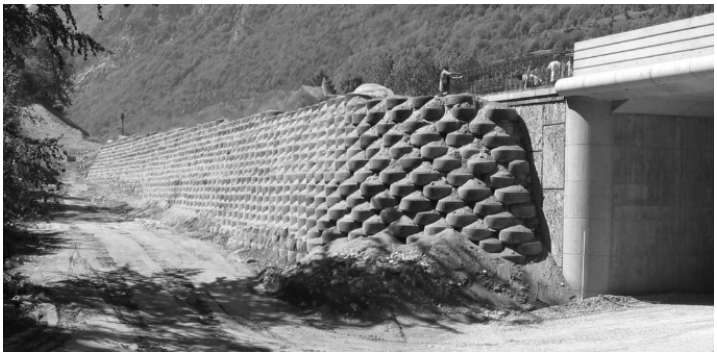


Fig. 2 – Pneutex system for the access ramps and the quarter-cones (personal archive foto).

The solution of using tires to make the facing is due primarily to the location of the passage near a slope, so the facing has performed the role of mitigating the impact energy from rock falls from the mountain.

3.2. Embankment for Roads Structures

To ensure the stability of a new embankment necessary for the enlargement of a village road the soil earth was used, in the Textomur mineral system, as an alternative to the original proposal, micropiles united among themselves with facing elements (Fig. 3) (Colț, 2014).

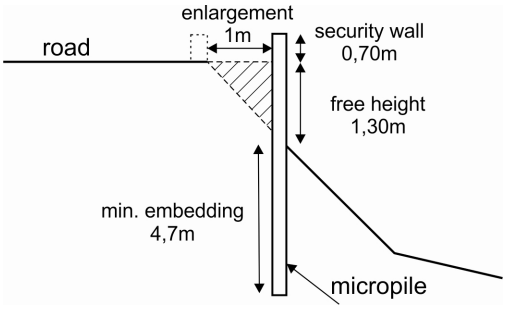


Fig. 3 – Retaining solution with micropiles.

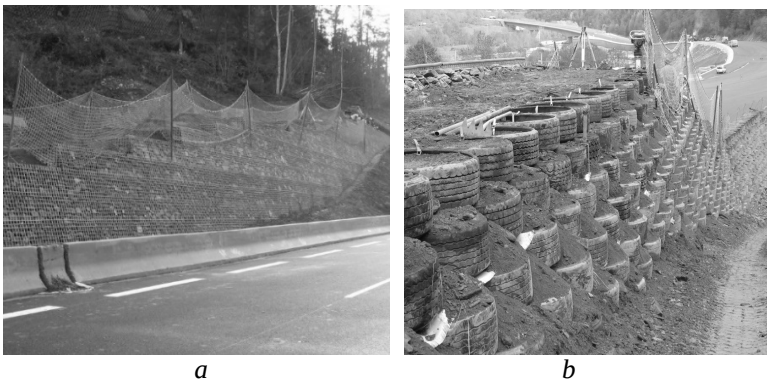
The construction of the reinforced soil retaining wall with a length of 75 m, width ≈ 3.5 m, height 3.60 m ≈ (Fig. 4), expected to be completed in 30 days, had a 1-week delay due to disruptions from the rainy days and the need to ensure drying the soil fill. However both the cost of work and working time in the reinforced soil solution were lower than those required to implement the solution with micropiles. In these case it is confirm once again the time and cost advantage of using a reinforced soil solution.

Fig. 4 – Picture from the construction site of the reinforced soil retaining structure (personal archive foto).

3.3. Retaining Structures/Walls for Road Works

Reinforced soil is successfully used in France to make retaining walls adjacent to roads. Thus in mountainous areas, where the use of a classical solutions (retaining walls made of concrete or reinforced concrete) is expensive, the use of reinforced soil structures, for which the local soil material may be used for the filling, can greatly reduce the final cost of the construction works.

As an example of the use of reinforced soil retaining wall in the projects regarding the construction of road structures, is presented the retaining wall from the project Centron Deviation RN90, France. The particularity of the presented work is given by that fact that the first half of the wall was a retaining wall, supporting the earth pressure (Fig. 5 *a*), and the second half of the reinforced soil structure had the purpose to protect the traffic against the rock fall from the mounting and of course to mitigate the impact energy (Fig. 5 *b*).



a *b*

Fig. 5 – Reinforced soil structure: left – the retaining wall in Textomur mineral, right – the Pneutex side (personal archive foto)

From this dual purpose of the reinforced soil structure, the working technology used was different for each side of the structure. For the facing near the road was used the Textomur mineral technology and for the facing near the slope, where it was necessary to reduce the energy of falling rocks, it was adopted the Pneutex system solution (Fig. 5 *b*).

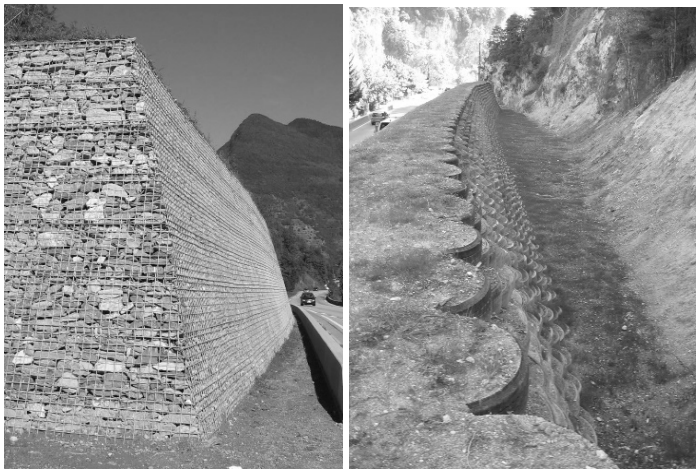
Fig. 6 – Reinforced soil retaining wall on A43 France (personal archive foto).

Another example for the use of reinforced soil solution afferent to a road project is the retaining wall build on A43 highway, a structure with a maximum height of 13.65 m, in steps, with the facing almost vertical using the Textomur mineral system with geotextile reinforcements (Fig. 6). This is a simple example to show the fact that the height of the retaining wall is not a problem in choosing this technical solution.

3.4. Reinforced Soil for Traffic Safety

In France a special interest is given to the traffic safety, so this way beside the retaining walls and reinforced soil embankments, in the road work projects there are preview construction works designated to increase the traffic safety for both participants to the traffic and those who live in the neighboring areas of the roads.

Thus in mountainous areas in the vicinity of the road where there is danger of falling rocks from on the road is projected retaining structures designated to mitigate the impact energy from the fall of stones, called Merlon. An example in this regard is a reinforced soil embankment double facing – one facing (adjacent to the road) of Textomur mineral (Fig. 7 *a*) and the facing adjacent to the slope on Pneutex – because the tires, with their flexibility, reduce the impact energy of the falling rocks (Fig. 7 *b*).



a b

Fig. 7 – Merlon (personal archive foto): *a* – textomur facing; *b* – pneutex facing.

With the purpose to increase the traffic safety and to ensure the safety of road-neighboring buildings, in addition to the primary purpose of retaining

the soil mass, reinforced soil retaining walls are built along the small curves (Fig. 8), especially in areas with increased risk of accidents (Colț, 2007).

Fig. 8 – Reinforced soil retaining structure (personal archive foto).

To these retaining structures attached to the role of stabilization, increase traffic safety, protection, an aesthetic function may be assigned. This can be achieved by the use of defined areas of vegetation on top of the structures thereby, also ensuring protection to the environment.

Fig. 9 – Reinforced soil structures for traffic safety (personal archive foto).

Traffic safety on public roads is affected by another problem: the loss of visual acuity giving the monotony of the landscape and of the route on long roads. A solution for these problem was found in the use of reinforced soil structures. For that, on the slopes adjacent to roads, were made flat areas where trees were planted, and to ensure the stability of the new slopes were used small reinforced soil retaining walls (Fig. 9), thus ensuring the landscape changes needed in order to increase visual acuity for the driver.

3.5. The Use of Retaining Walls in Order to Reduce the Pressure on Buildings

For the situation where the building site have a slope profile, a plain surface may be made only for the building plane surface and in these case the upstream earth is pushing directly on the building, thereby increasing the loads on the structure and of course on the foundation soil. In order to solve this deficiency it may be used a retaining wall positioned nearby upstream and outside of the building, with the purpose to stabilize the slope, and to reduce the pressure acting on the foundation soil.

An example for this case is a reinforced soil retaining wall, made in the project of restoration and extension of a hotel in the Peisey - Nancroix, France, where it was neededto change the height of the structure by building a new floor and arranging a platform around the building (Colț, 2014).

It was necessary to decrease the net pressure on the footing and the solution was found in limiting the earth pressure from the upstream earth acting on the old structure by creating a retaining wall slightly offset from the building wall. The adopted solution was a retaining wall made in Textomur system with a neutral facing approximately vertical, 5.50 m height, corresponding to 9 levels of Textomur (Fig. 10). For the filling material, the local soil was used but only after crushing and sieving it, to ensure an efficient compaction.

Fig. 10 – Retaining wall for limiting the thrust (personal archive foto).

5. Conclusions

The composite material reinforced soil, known and used in an archaic form thousands of years, is now considered a relatively recent material but it was already proven by the versatility and advantages of the many outstanding works made since the patenting of it until today. The various technologies

created over time for construct these type of works are the testimonials. Ability to create supple and light structures, with small curves, using local materials with relative simple working equipment creates prerequisites support for expanding the use of reinforced soil structures in various fields of construction, yet without forgetting the limitations and disadvantages of this solution.

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UTILIZAREA STRUCTURILOR DE SPRIJIN DIN PĂMÂNT ARMAT ÎN CONSTRUCȚII – EXEMPLE

(Rezumat)

Pământul armat este un material compozit (pământ de umplutură – armătură) utilizat atât la lucrări de stabilizare a pantelor cât şi ca structuri de susținere. Avantajele pe care le crează soluțiile tehnice ce au la bază pământul armat, atât din punct de vedere economic cât şi a posibilității de adaptare la cerințele finale ale lucrării, comparativ cu cele uzuale, clasice, au determinat o extindere a utilizării structurilor de susținere din pământ armat în diverse domenii ale lucrărilor de construcții (sferturi de con şi rampe de acces la poduri, ramblee de căi ferate sau rutiere, ziduri de sprijin aferente infrastructurii de transport, baraje, diguri, structuri de protecție).