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

Case Histories of TRMs with Double Twisted Wire Mesh Reinforcement

Marianna Ferrara,[1] Stefano Rignanese,[2]
Aigen Zhao, PhD, P.E.,[3] and Davide Invernizzi[4]

[1]Maccaferri Inc., Rockville, MD, USA, 20850; e-mail: mferrara@maccaferri-usa.com
[2]Maccaferri Inc., Rockville, MD, USA, 20850; e-mail: srignanese@ maccaferri-usa.com
[3]Maccaferri Inc., Rockville, MD, USA, 20850; e-mail: azhao@maccaferri-usa.com
[4]Maccaferri Inc., Sacramento, CA, USA, 95834; e-mail: dinvernizzi@maccaferri-usa.com

ABSTRACT

Erosion control is one of the biggest challenges for soil conservation in rivers, channels, agriculture and infrastructure. Soil erosion is a natural process, however accelerated erosion can occur when human activities create disequilibrium in the environment. Soil erosion can cause several problems including decreases in agricultural productivity and eutrophication of waterways. Soil erosion often causes damage to civil infrastructure and accelerates desertification and sedimentation. Among the existing solutions for erosion control, geosynthetics serve as an effective and economical option. High performance Rolled Erosion Control Products (RECPs) are designed for critical erosion control applications in high flow velocity channels, stream banks, and on steep slopes. Double-twist wire mesh can be incorporated within the filaments of geomats during production, enhancing their performance against erosion and providing additional reinforcement. Incorporating double twisted wire mesh into the geomat increases resistance to shear forces, high velocity flow, extended UV exposure, and heavy traffic loading. This product is flexible and easy to install, and it gives a strong protection against erosion while promoting vegetation growth. This paper presents properties, applications and case histories of the geomat with double twisted wire mesh reinforcement.

INTRODUCTION

Erosion is a form of soil degradation and is characterized by detachment, transport, and deposition of soil particles. This process occurs naturally at low rates in all soils by forces of water and wind. Environmental factors such as climate, vegetation, soil characteristics, and topography are major factors in natural erosion rates. Human activities, however, can dramatically increase the rates of soil loss by means of urbanization, over cropping, overgrazing, and deforestation. Soil erosion has become a global issue because of decreases in agricultural productivity, increased damage to civil infrastructure, siltation of water ways and reservoirs, and water and air pollution. Global climate change is also expected to lead to a warmer and wetter atmosphere in the future, conducive to larger and more frequent storms leading to higher amounts of runoff and erosion. These adverse economic and environmental impacts highlight the need for proper erosion control solutions. One of the most effective ways to combat erosion is to minimize the disturbance of existing soils, retaining as much existing vegetation as possible, especially near water bodies and on steep slopes.

Geosynthetics accomplish this by creating a physical barrier which absorbs the impact of water and wind on soils, resulting in the prevention of soil loss and enhances vegetation growth. Rolled Erosion Control Products (RECPs), as shown in Figure 1, are easy and fast to install, and can be applied directly onto slopes and along river and canal banks, conforming to the shape of the banks due to their flexibility.

RECPs can be made of natural fibers (biomats) which are kept together by natural or synthetic low weight nets. Biomats are considered a temporary solution. They absorb large amounts of water and during their natural degradation, they decompose and produce nutritious materials for the vegetation. RECPs can also be made of synthetic nets, fibers or filaments tangled together (geomats). These geomats are considered a permanent solution and form a high porosity deformable layer that is 10 - 20 mm thick. Geomat RECPs are also known as Turf Reinforcement Mats (TRMs).

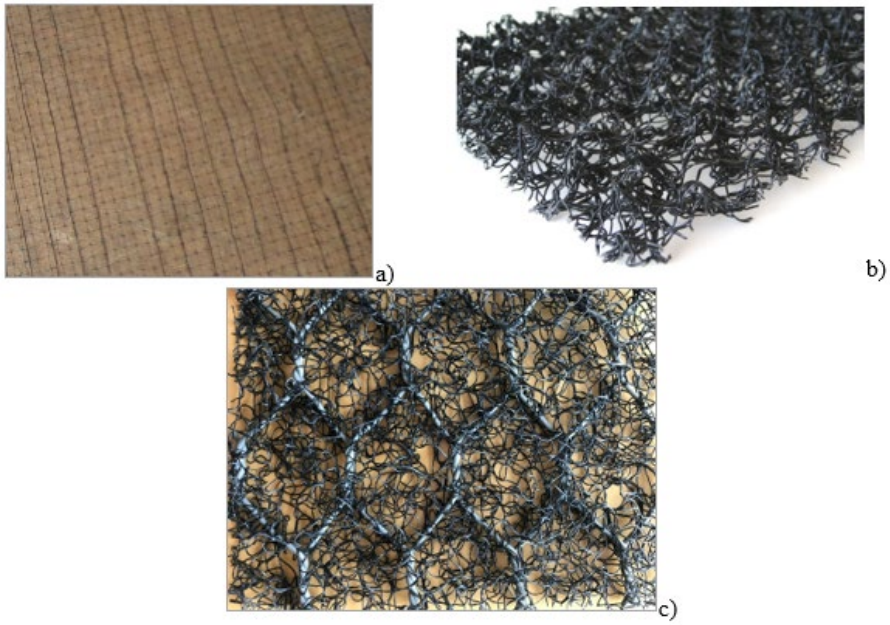

Figure 1. Examples of geosynthetics for erosion control: a) biomat, b) geomat and c) geomat with DTWM reinforcement.

In addition, there is a reinforced version of these permanent RECPs. The reinforcement can be a geogrid or a metallic mesh. The TRM with metallic reinforcement is manufactured by extruding synthetic filaments onto a double twist steel wire mesh (DTWM). This significantly increases the tensile strength of the geomat so it can be used on long and steep slopes and along the banks of canals and river courses with high water velocities. Properties of this product are shown in Table 1.

Table 1. Physical and mechanical properties of the Geomat with DTWM reinforcement.

GEOMAT	Polymer	PP	
	Mass / Unit area ASTM D6566	450 g/m^2	
REINFORCEMENT	Double Twist Mesh Type	6x8	8x10
	Wire Coating	95% Zn - 5% Al alloy (+ PVC if needed)	
GEOCOMPOSITE	Tensile Strength ASTM D4595	37 kN/m	50 kN/m
	Nominal Thickness ASTM D6525	12 mm	

Geomat with woven steel wire mesh reinforcement works as a TRM, shielding the soil slopes from the effects of wind and rainfall and prevent the wash out of soil particles before vegetation is established (see Figure 2). At the same time, the presence of the double twist steel wire mesh provides higher tensile strength and shear resistance and protects the geomat from potential damage. Also, if a cut occurs in the geomat it will not propagate through the entire product. Instead, it will be limited to just a single mesh opening.

Figure 2. Unravelling effect of the woven mesh.

Additionally, double-twist steel wire mesh reinforcement helps establish TRM continuity during the installation phase by joining the edges of the adjacent steel meshes without overlapping (see Figure 3). It also facilitates the connection of the product to other structures along or at the bottom of the slope, improving anchorage and protection where stresses are concentrated, and erosion is usually more critical.

Figure 2. Geomat with DTWM reinforcement on a steep soil slope before and after the establishment of vegetation.

Figure 3. Connection of geomat with DTWM adjacent rolls without overlapping detail.

Hence, geomats with double-twist steel wire mesh reinforcement have a wide spectrum of applications: from regular soil slopes (2:1 or less) to very steep slopes (more than 1:1), and in combination with soil nails; from lining of irrigation channels to river banks protection. In addition, DTWM reinforced geomats can be used in rockfall mitigation systems.

SLOPE STABILIZATION IN ANAHEIM, CALIFORNIA

Soil nailing is a widely used technique to reinforce and strengthen steep slopes and consists of inserting reinforcing bars directly into the ground at optimal inclinations. In soil nailing applications, the facing element is often required to provide both tensile strength and erosion control. To accomplish this, shotcrete is commonly used. However, shotcrete stabilized slopes are rigid, and require the installation of a proper drainage system to prevent the build-up of pore water pressures behind the slope. Geomats with double twist steel wire mesh reinforcement not only meet the erosion control and tensile strength requirements for slope stabilization, but are also flexible, permeable, and very easy to install. This system can be installed in just one-time

application, cutting down installation time and associated installation costs. This is very important because soil nailing for slope stabilization is often used to protect infrastructure like highways and roads. It is difficult and costly to temporarily close a single lane or an entire road, especially due to the high costs and economic impact associated with traffic control and road closures.

A double twist wire mesh geomat solution was installed adjacent to North Santiago Boulevard, in Anaheim, California. North Santiago Boulevard is a major expressway linking several residential and commercial developments. At the intersection with E. Nohl Ranch Rd, there is a steeply cut slope that is highly erodible and prone to frequent mud slides. Previously, the slope had been covered with different light weight erosion control blankets, yet erosion was still actively occurring. The designer selected a soil nailing application in combination with the geomat with woven steel wire mesh reinforcement to stabilize the face of the slope. a network of 3-meter-long soil nails were grouted into 8 cm diameter drillholes and organized into an array with 2 m vertical and horizontal spacing. It was possible to apply hydromulch and hydroseeding, as shown in Figure 4, on top of the geomat with DTWM, thanks to its permeable characteristics, to enhance and facilitate vegetation growth on the slope.

Figure 4. Soil Nailing system with geomat with DTWM reinforcement and hydromulch before and after the growth of vegetation.

CULVERT AND CHANNEL PROTECTION IN FORT WORTH, TEXAS

Geomats with woven steel wire mesh reinforcement are also used to line the banks of channels and canals and protect them from erosion due to flowing water. The geomat with DTWM reinforcement creates a protective layer which increases the shear strength of the soil on the surface of banks while reducing the velocity of flow along the channel section. This type of geomat is a permanent solution that can resist up to 2.5-3 m/s flow velocities, depending on the geomat thickness and the flood duration. The strength of the woven steel wire mesh reduces the ‘uplifting’ of the geomat when exposed to aggressive hydraulic flows. Stresses generated at the geomat anchor points are dissipated by the reinforcing mesh.

The geomat with DTWM reinforcement was installed on a creek bank in Fort Worth, Texas, to reduce erosion along the slopes. The development of a new residential neighborhood caused the impermeabilization of a large area, and therefore caused the formation of significant storm water runoff during heavy rainfall events. The nearby creek was having severe erosion problems due to the excessive runoff, geomat with DTWM reinforcement was installed on the creek banks, in combination with gabions installed directly outside the newly installed box culvert, as shown in Figure 5. The selected TRM had a double twist steel wire mesh with a combined metallic and polymeric coating to ensure long-term corrosion and abrasion resistance of the solution. A trench was prepared to ensure anchoring at the top of the slope, and threaded steel bars with plates were used to fix the TRM to the slope. The TRM then was fixed to the gabions at the bottom of the creek for improved stability and anchoring, leading to optimal protection in the weakest part of the section.

Figure 5. Geomat with DTWM reinforcement hydraulic application.

ROCKFALL MITIGATION AND SLOPE STABILIZATION CLOSE TO QUITO, ECUADOR

Double-twist wire mesh is widely used in mitigating small rockfall events (rock diameter up to 0.6 m). When a slope is made of a mix of fine soil particles and small rocks, it is not only important to contain the rocks from falling, but it is also necessary to control the erosion process caused by rainfall and wind impact. Generally, in these types of slopes, erosion is the real triggering factor for the rockfall event, so it is fundamental to mitigate the erosion process to prevent the risk of rocks falling. As already mentioned, the geomat with double twist steel wire mesh reinforcement combines both erosion protection and rockfall mitigation, so can be applied on the slopes previously described.

An example of this application is in Ecuador. After a magnitude 5.1 earthquake struck the Ecuadorian province of Pichincha, between the capital, Quito and Guayllabamba, landslides made some roads unserviceable. With the epicenter in the immediate vicinity and the risk of further landslides, the Ministry of Transportation and Public Works closed the roads to allow slope stabilization work to be carried out on the embankments. The cause of the landslides was attributed to the soils weakened by erosion from wind, water, and the earthquake. A geomat with double twist steel wire mesh reinforcement was selected to prevent soil loss and occasional larger rocks (up to 25cm diameter) from falling from the slope (see Figure 6). The use of a

flexible and permeable system also enabled the slope to revegetate, and additionally, provide root reinforcement to the vegetation.

Figure 6. Installation of a geomat with DTWM reinforcement on a rocky slope.

CONCLUSION

Geosynthetics for erosion control are very versatile products that can be easily applied on slopes, providing immediate protection to bare soils. Among the TRMs, geomats with DTWM reinforcement are one of the most resistant erosion protection products. These TRM systems have a higher tensile strength and shear resistance, compared to non-reinforced geomats, and maintain their flexibility. In addition, the presence of the steel reinforcement guarantees long-term durability and performance even in adverse conditions. These systems can perform on high and steep slopes, where vegetation doesn't have the possibility to establish uniformly, and on channel or river banks with high flow velocities and shear stresses. These DWTM reinforced TRM systems can also perform on steep slopes made of a mix of fine soil particles and small to medium size rocks. The combination of a geomat and a woven steel wire mesh is also environmentally friendly. Vegetation can grow through the system either naturally or with the help of hydroseeding. When the vegetation is established, the roots anchor the geomat to the slope, and the steel mesh provides a stronger protection capable of handling steeper slopes and higher run-off flow velocities. Furthermore, the case studies presented in this paper show that the installation of the system is easy and fast, in just one-time the geomat and the DTWM can be applied on the slope cutting installation time and labor costs, while also improving the safety conditions of the workers.